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The WHAT'S NEW magazine

APRIL 1989

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IT'S A LOT OF TRUCK FOR THE MONEY.

With so many new features—and some returning favorites like a fully synchronized five-speed trans-

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nission, power steering, tinted glass, and AM/FM stereo cassette –you might think Ranger XLT can't possibly be a bargain. But Ranger XLT gives you all that, plus Twin-I-Beam Front Suspension, 60/40 cloth split bench, and all-season radials for a price that ust might surprise you.

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This One

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APRIL 1989
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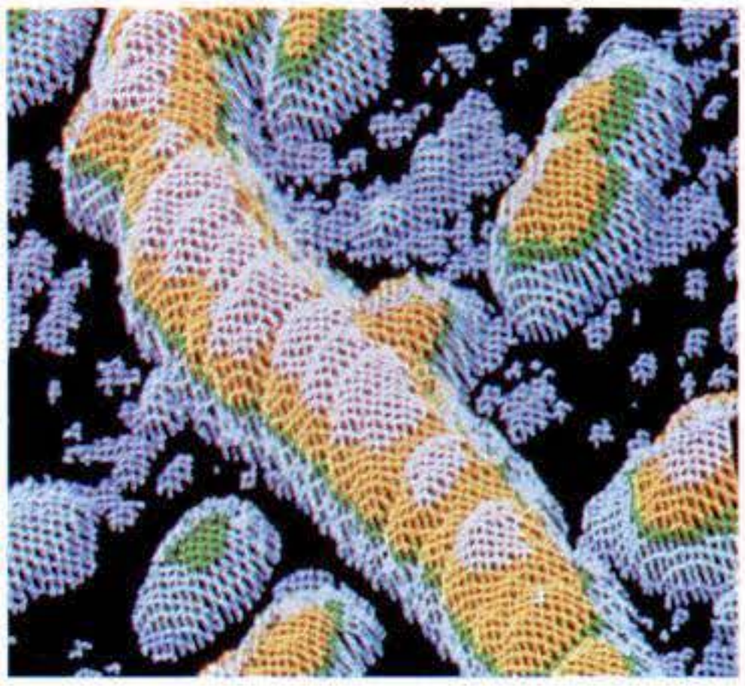
Seeing atoms

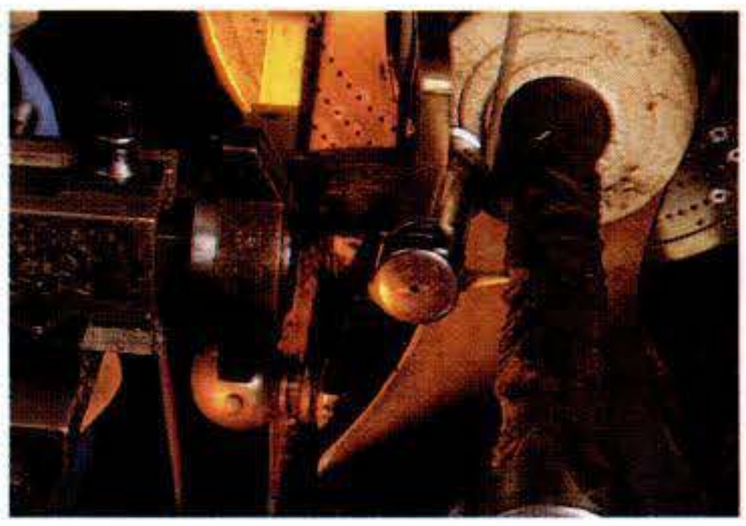


A series of advances has led to microscopes that can see an atom whose diameter is four billionths of an inch. These devices, the scanning tunneling microscope and the atomic force microscope, enable scientists for the first time not only to map a surface's atomic structure, but explore electronic properties of atoms individually. **Page 102**

Show stoppers

From the sleek California Camaro to the technology-filled Chrysler Millenium to the fun Ford Splash, Detroit shows eye-popping designs at its annual auto show. **Page 108**

Ultimate lathe



The ornamental lathe: It is to tools what Lamborghini is to cars, what Fabergé is to jewelry. With today's high-tech marvels, it's startling that it was invented in 1794 and last made in 1914. Now there will be a modern rendition. **Page 116**

Summer houses

Commissioned from five prizewinning architects, the homes in this portfolio, which can all serve as primary housing, comfortably embrace today's technologies and bolder sense of design without sacrificing traditional comforts. **Page 128**

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Readers Talk Back

Ozone addenda

The credibility of your magazine shot way up, in my opinion, after I read "The Man Who Knew Too Much" [Jan.]. Considering the damage resulting from the environmentally destructive things we are doing to the only home we have, all publications have a responsibility to make their readerships aware of our planet's impending demise.

David Fraser
Edmonton, Alberta, Canada

In the January issue the article on the danger to Earth from the destruction of ozone is followed later by an article ["Water-Based Varnish"] in which the EPA labels ozone a "dangerous pollutant." If chlorofluorocarbons are destroying the vital ozone shield, and volatile organic compounds in varnish react with nitrogen oxides to form ozone, why not release more of these VOCs to remedy the problem?

William J. Waddell, M.D.
Prospect, Ky.

Even if all chlorofluorocarbon use were to stop now, there is already enough of the gas released in the air to affect the ozone layer for decades. However, ozone is as cheap to produce as commercial oxygen and we have aerial tankers, so why not simply release compressed ozone at high altitude?

The Rev. Timothy Michell
Lafayette, Ore.

We received many letters like Dr. Waddell's. Ozone is indeed vital to life, but only in the right place. The ozone depletion concerning atmospheric scientists occurs 10 to 40 miles above the surface of Earth. Ozone here absorbs ultraviolet light, serving as a shield from lethal radiation. Breathing excessive quantities of ozone at or near Earth's surface, however, can damage lung tissue. Many readers have also made the same suggestion as Michell. But the volume of ozone needed is too immense to make any such attempt feasible. —Arthur Fisher

Floating airplanes

After reading the letter from 1st Lt. Kenneth Ferguson criticizing the use of a ballistic chute on aircraft ["RTB," Feb.], I had to respond. I have been flying for 20 years and consider the ballistic-chute system probably the greatest invention for aviation in a long time. I own an ultralight and I fly it all the time. I appreciate any safety system that could save my life. Even if airplanes started floating down out of the sky on their chutes and landing in backyards, shopping centers, and freeways, at least there would be only minor injury to both pilot and plane.

Gary Safrit, Mount Pleasant, N.C.

Explaining X-31

Congratulations on your clear and concise article on our Enhanced Fighter Maneuverability program to build and test two X-31 combat capability demonstrator aircraft [Cover article, Feb.]. Jim Schefter was able to put the concepts of agility and post-stall maneuverability into terms readily understandable—a task we have often found difficult even when talking to knowledgeable audiences. And to cap it off, the illustrations by Mark McCandlish were outstanding.

Dave Moruzzi, marketing manager
Rockwell International Corp.
Arlington, Va.

Can L-Drives take it?

"Space-Saving Stern Drive" [Dec. '88] did not cover what happens when an underwater obstruction is encountered by the new L-Drive. Hitting a log might well sink the boat by ripping off the aft keel or stern. My inboard-outboard motor can "kick up" when obstructions are encountered.

James R. Holt, Cincinnati, Ohio

The L-Drive has an impact-unloading circuit in the hydraulic system and the ability to tilt up 53 degrees when making contact with a submerged object. We have completed controlled-impact tests with a 12-inch-diameter log 18 feet long at 25 mph with only minor damage to the unit.—Dave Gruenwald, manager of four-cycle engineering, US Marine Power Corp, Hartford, Wis.

Amazing ant

I was amazed by your description of the Fire Ant anti-tank weapon in the January "Science Newsfront." Where's

Continued

Address letters for this column to: Readers Talk Back, POPULAR SCIENCE, 380 Madison Ave., New York, N.Y. 10017. We are unable to acknowledge unpublished letters.

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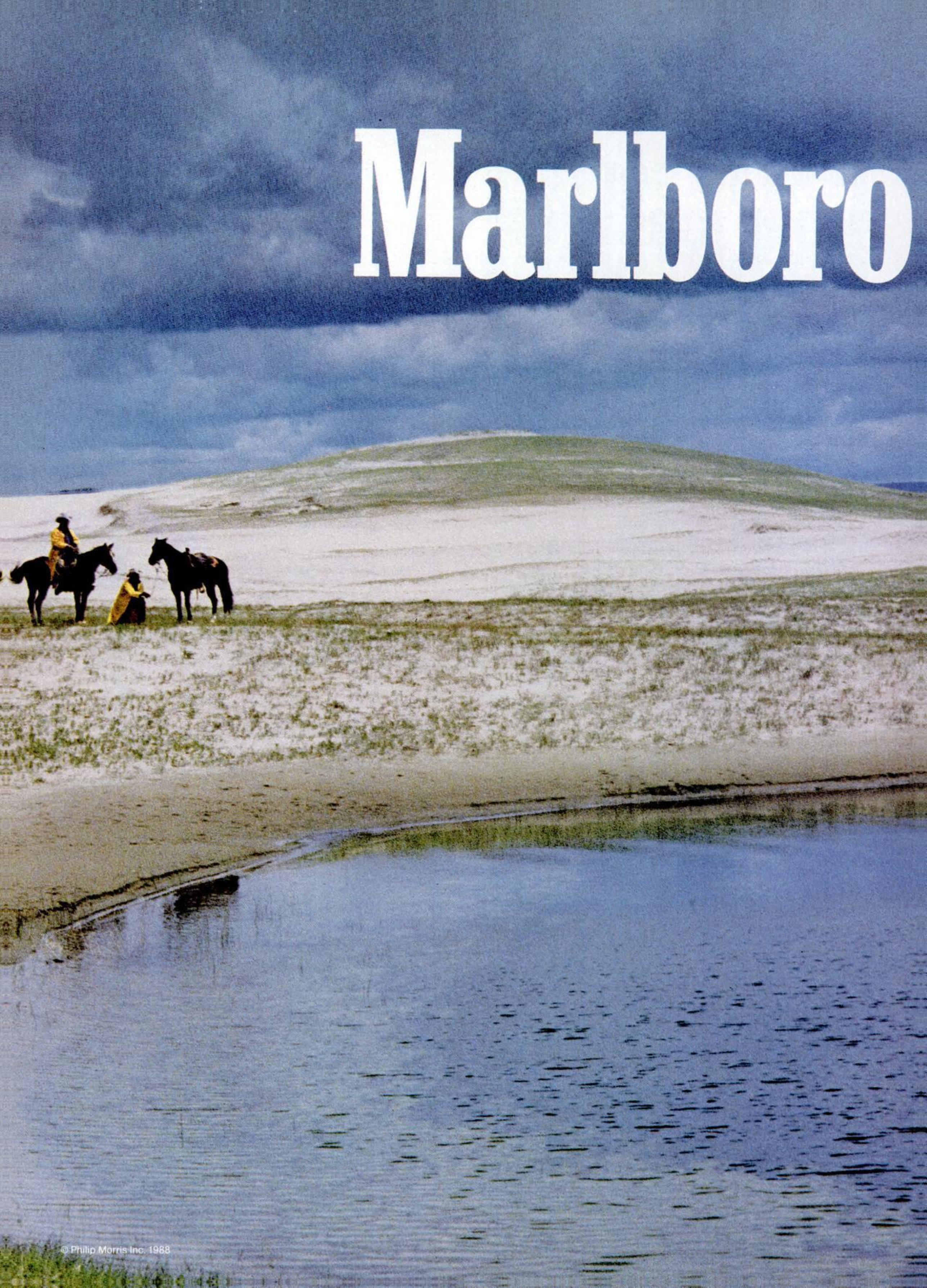

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Lights

The spirit of Marlboro in a low tar cigarette.

SURGEON GENERAL'S WARNING: Quitting Smoking Now Greatly Reduces Serious Risks to Your Health.

10 mg "tar," 0.7 mg nicotine av. per cigarette, FTC Report Feb.'85

the heavy breech and barrel assembly to propel the 22-pound copper projectile at a velocity of 6,600 feet per second? That number must be a mistake. After all, a 40-mm cannon projectile, at nearly that weight, achieves only one-third that velocity from a heavy barrel several feet long. Let's have some more data on the machine.

J. M. Jones, Autaugaville, Ala.

The velocity given is not a mistake. It is the result of the explosion of a shaped charge that instantaneously melts the copper projectile and hurls the resulting glob of metal at high speed. The vehicle itself, considered low-cost and expendable, is disintegrated in the process.—Arthur Fisher

High-strung table

February's "Wordless Workshop" has a serious flaw. As shown, the stringing of the table necessitates a great amount of slack, as all the string (or wire) has to be pulled through all the holes until it reaches the last one. Staples or parallel saw cuts would have been adequate and much easier.

Pete Howley, Jacksonville, Fla.

Fuel-efficient Ford

According to Fred W. Hunt ["RTB," Feb.], who wants to see pollution-free cars, "We need 230-horsepower cars like we need holes in the head!" The only foolproof way to control emissions is to use all available energy in the fuel. This, in turn, means getting more power from a given displacement. When Ford introduced its own V6 a few years back, it barely exceeded 100 horsepower. The new SHO engine makes 230 hp from the same displacement and, from the reports I've seen, does it on less fuel. Am I missing something, Mr. Hunt?

Bradly Johnson, Paducah, Texas

The end of the tale?

I'd like to set the record straight for Warren G. Seitzinger and John J. Leggio ["RTB," Tool Tales, Sept. '88]. POPULAR SCIENCE did not claim the split shank idea on the Gripping Driver screwdriver to be new. The new feature is the dovetail on the screwdriver's tip, and it works differently from any other screwdriver.

Earl Benitz, Leavenworth, Kan.

First bus

Contrary to your statement in December 1988's "Electronics Newsfront" [Forced Busing], the computer bus did not get its start at IBM. The first use of a computer bus that I can find was on the Whirlwind I at the Massachusetts Institute of Technology. This computer was begun in 1947 and was used from 1950 to 1967. It brought in other innovations, as well, such as tape, drum, and core memory.

Dale Dellutri, Evanston, Ill.

Scary spare parts

After reading your article "The Econocar Redefined" [Nov. '88], I am bothered over the cost of replacement parts. A price of $472 for the Corolla alternator—a bit of metal with perhaps $5 worth of wire, some brass, a couple of diodes, and maybe $3 worth of bearings—is astronomical. As a former electrical contractor, I am in shock.

Joe Frackt
Montreal, Quebec, Canada

I read your car-test article "Wet Set" [Dec. '88], and I was disappointed that while you tabulated some interesting information, you failed to comment on a major failing of these cars. I refer to the ridiculous pricing of spare parts for the vehicles. Almost $600 for a Subaru alternator is unpalatable at best.

Brad Cozad, Los Osos, Calif.

Exhausting radon

Reader Warnek ["RTB," Jan.] disputed the findings of Lawrence Berkeley Laboratory's study of heat-recovery ventilators, which was based on the correct use of an HRV ["Give Your House a Breather," Oct. '88]. When Warnek plugged " 'the warm, stale air' side of the HRV into the floor," he converted his HRV into a sub-slab ventilation system, which the EPA has documented as an effective way to reduce indoor radon. But unless Warnek has expended the HRV's outdoor exhaust above his house's eaves, he could be causing a radon-level increase in other sections of his home and/or exposing people or animals in the exhaust area to high radon levels. He has also reduced the efficiency of the HRV by drawing cold air from under the slab into the ventilator's heat-recovery side.

Rick L. Formenti, address withheld

Corrections: The Ford F-150 pickup shown on page 45 of the February issue is a standard cab, not a Supercab.

Regarding T. A. Heppenheimer's response to a letter about the hypersonic spy plane in February's "RTB," the speed of sound has a sea-level value of 760 mph at 158,000 feet. PS

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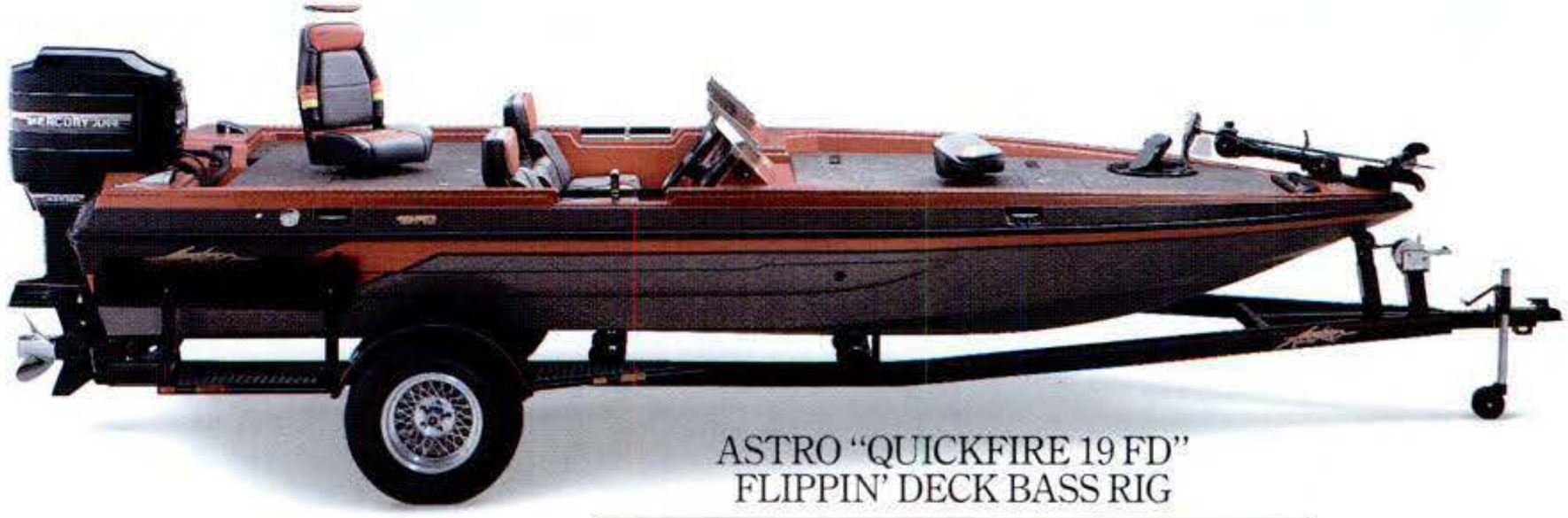

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When it comes to a complete line of fully-rigged aluminum fishing boats, you'll have to look long and hard to match Astro. With 23 different aluminum Astros to choose from, you're sure to find the rig that's decked out for your kind of fishing. From V hulls for taming big waves to flat bottoms for working your favorite lake. Once you compare an Astro aluminum rig to the same type package from another boat manufacturer, you'll find there's no comparison. Or better value.

And that's true when it comes to your Astro dealer as well.

It's just hard to find a more knowledgeable, professional dealer around. You'll get help and advice you can really use. Plus, there's all the support, service, parts and accessories you'll need to keep you on the water.

See the back page for complete specifications on the full Astro aluminum line of fishing rigs. For free information and the location of your nearest Astro dealer, call **1-800-BOATS-90**.

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ASTRO "LAKESPORT 14" FLAT BOTTOM RIG

$2,599 or as low as $55.77 per month.*

☐ Classic flat bottom aluminum design ☐ Reliable Mercury 15 hp outboard ☐ Custom-matched drive-on trailer

ASTRO "BASSPORT 16"
MODIFIED V BASS RIG

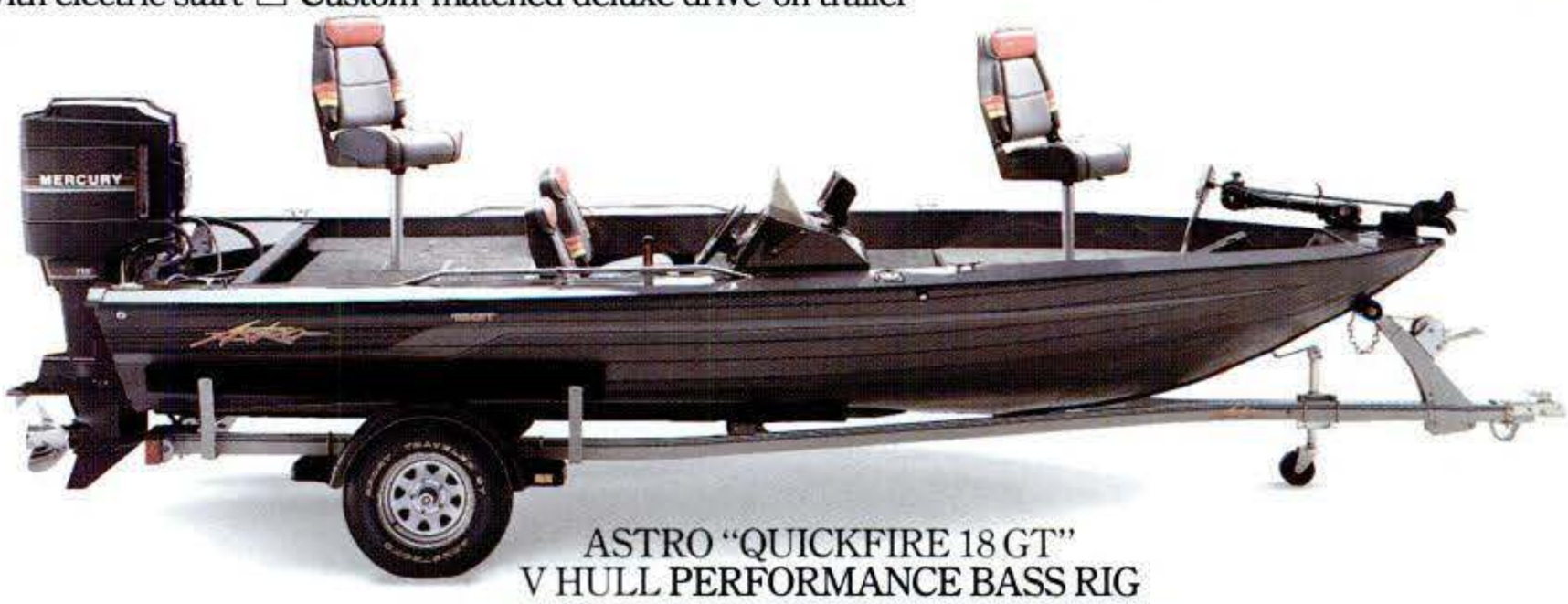
$6,799 or as low as $98.92 per month.*

☐ Smooth entry modified V-hull design ☐ Four marine grade vinyl covered fishing seats ☐ Rear aerated livewell ☐ Deluxe dash instrumentation panel complete with Quicksilver™ tachometer, speedometer, volt and water temperature gauge ☐ Lowrance X4 LCR on swivel base ☐ 12V Mercury Thruster® foot control trolling motor ☐ Marine carpet over all-aluminum floor and deck panels (no wood) ☐ Double-anchored "spring-loaded" pedestal bases ☐ Performance-matched Quicksilver™ stainless steel propeller, standard ☐ Deep-cycle trolling motor battery and cranking battery with trays ☐ Smooth running Mercury 40 hp outboard with power trim and tilt ☐ Custom-matched deluxe drive-on trailer

ASTRO "LAKESPORT 16 V DLX"
VEE HULL RIG

$4,999 or as low as $107.27 per month.*

☐ Wave Tamer™ aluminum V-bow design ☐ Two marine grade vinyl covered pedestal fishing seats ☐ Aerated livewell ☐ Quiet, powerful Mercury Thruster® trolling motor ☐ Lowrance X4 LCR on swivel base ☐ Marine carpet over all-aluminum floor panels (no wood) ☐ Double-anchored pedestal bases ☐ Deep-cycle trolling motor battery and cranking battery with trays ☐ Dependable Mercury 25 hp outboard with electric start ☐ Custom-matched deluxe drive-on trailer



ASTRO "QUICKFIRE 18 GT"
V HULL PERFORMANCE BASS RIG

$11,999 or as low as $174.58 per month.*

☐ New design concept in lightweight, high-performance aluminum hulls ☐ Dual aerated livewells with timers ☐ Built-in 22-gallon fuel system ☐ All aluminum floors and decks (no wood) ☐ Deluxe dash instrumentation panel complete with Quicksilver™ tachometer, speedometer, volt and water temperature gauges ☐ Lowrance X4 LCR on swivel base ☐ Mercury Thruster® 24/12 foot control trolling motor with Whisper Drive™ system and Machete™ prop ☐ Double-anchored "spring-loaded" pedestal bases ☐ Performance-matched Quicksilver™ stainless steel propeller, standard ☐ Two deep-cycle trolling motor batteries and cranking battery with trays ☐ Top-performance Mercury 115 hp outboard with power trim and tilt ☐ Custom-matched deluxe drive-on trailer

Call **1-800-BOATS-90** for free information and the Astro dealer nearest you. *See back page for financing information.

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THERE'S AN ASTRO FISHING RIG TO MEET YOUR SPECIFICATIONS

Astro Aluminum Fishing Rigs

	Mercury Outboard	Power Trim	Estimated Monthly Payment/Term (See Note 1)	Length	Beam	Mercury Thruster Trolling Motor	Quicksilver Propeller†	Full Quicksilver Instrumentation	Fish Locator: Lowrance X4	Fish Locator: Lowrance 1240 In Dash	Marine Batteries	Fuel Capacity	Custom Drive-on Trailer	As Low As (See Note 2)
FLAT-BOTTOM RIGS Lakesport fishing rigs for serious fishermen on a budget.														
Lakesport 14	5 hp		**$40.75/48 mo**	14′	54″		AL					6 gal	*	$ 1,899
Lakesport 14	15 hp		**55.77/48 mo**	14′	54″		AL					6 gal	*	2,599
Lakesport 15	9.9 hp		**57.92/48 mo**	15′	62″		AL					6 gal	*	2,699
Lakesport 15	20 hp		**64.35/48 mo**	15′	62″		AL					6 gal	*	2,999
VEE HULL RIGS Tough, versatile, V-bottom rigs.														
Lakesport 14V	9.9 hp		**$ 62.21/48 mo**	14′	59″		AL					6 gal	*	$ 2,899
Lakesport 14V DLX	15 hp		**79.37/48 mo**	14′	59″	12V	AL		*		1	6 gal	*	3,699
Lakesport 14V DLX	25 hp		**85.81/48 mo**	14′	59″	12V	AL		*		1	6 gal	*	3,999
Lakesport 16V DLX	20 hp		**100.83/48 mo**	15′11″	67″	12V	AL		*		1	6 gal	*	4,699
Lakesport 16V DLX	25 hp		**107.27/48 mo**	15′11″	67″	12V	AL		*		2	6 gal	*	4,999
Lakesport 16V Special	25 hp		**122.29/48 mo**	15′11″	67″	12V	AL	*	*		2	6 gal	*	5,699
DEEP V HULL WALLEYE RIGS Designed for walleye and big water lakes.														
Lakesport 16V PRO	25 hp		**$128.73/48 mo**	16′2″	76″	12V	AL	*	*		2	6 gal	*	$ 5,999
Lakesport 16V PRO	50 hp	*	**116.38/84 mo**	16′2″	76″	12V	S.S.	*	*		2	6 gal	*	7,999
Lakesport 18V PRO	80 hp	*	**160.03/84 mo**	18′2″	84″	24/12V	S.S.	*	*		3	22 gal	*	10,999
Lakesport 18V PRO SPECIAL	80 hp	*	**171.67/84 mo**	18′2″	84″	24/12V	S.S.	*	*		3	22 gal	*	11,799
MODIFIED V CRAPPIE RIG A special Lakesport for crappie fishermen who prefer aluminum.														
Lakesport 16 DLX	**25 hp**		**$102.98/48 mo**	**16′**	**69″**	**12V**	**AL**		*		**2**	**6 gal**	*	**$ 4,799**
MODIFIED V BASS RIGS Classic, pro-equipped bass boats.														
Bassport 16	25 hp		**$115.85/48 mo**	15′7″	62″	12V	AL	*	*		2	6 gal	*	$ 5,399
Bassport 16	40 hp	*	**98.92/84 mo**	15′7″	62″	12V	S.S.	*	*		2	6 gal	*	6,799
Bassport 16 PRO	35 hp		**91.65/84 mo**	16′	69″	12V	AL	*	*		2	6 gal	*	6,299
Bassport 16 PRO	50 hp	*	**112.01/84 mo**	16′	69″	12V	S.S.	*	*		2	6 gal	*	7,699
V HULL PERFORMANCE BASS RIGS Light, fast and loaded for lunkers.														
Quickfire 16 GT	40 hp	*	**$126.56/84 mo**	16′	73.5″	12V	S.S.	*	*		2	12 gal	*	$ 8,699
Quickfire 16 GT	70 hp	*	**145.48/84 mo**	16′	73.5″	12V	S.S.	*	*		2	12 gal	*	9,999
Quickfire 18 GT	80 hp	*	**160.03/84 mo**	17′10″	82″	24/12V	S.S.	*	*		3	20 gal	*	10,999
Quickfire 18 GT	115 hp	*	**174.58/84 mo**	17′10″	82″	24/12V	S.S.	*	*		3	20 gal	*	11,999

Astro Quickfire Polyglass Fishing Rigs

QUICKFIRE CRAPPIE STYLE RIGS Versatile fishing rigs.														
15CR	35 hp		**$109.01/84 mo**	15′5″	76″	12V	AL	*	*		2	12 gal	*	$ 7,299
15CR	60 hp		**120.74/84 mo**	15′5″	76″	12V	AL	*	*		2	12 gal	*	8,299
16CR	80 hp	*	**145.48/84 mo**	16′4″	80″	12V	S.S.	*	*		2	12 gal	*	9,999
QUICKFIRE SINGLE CONSOLE BASS RIGS True classics, our best sellers.														
15SC	60 hp	*	**$130.93/ 84 mo**	15′5″	76″	12V	S.S.	*	*		2	12 gal	*	$ 8,999
16SC	70 hp	*	**139.66/ 84 mo**	16′4″	80″	12V	S.S.	*		*	2	17 gal	*	9,599
17SC	90 hp	*	**160.03/ 84 mo**	16′10″	82″	24/12V	S.S.	*		*	3	24 gal	*	10,999
17SC	115 hp	*	**167.30/ 84 mo**	16′10″	82″	24/12V	S.S.	*		*	3	24 gal	*	11,499
18SC	115 hp	*	**151.63/120 mo**	18′	86″	24/12V	S.S.	*		*	3	24 gal	*	12,699
18SC	150 XR4	*	**167.15/120 mo**	18′	86″	24/12V	S.S.	*		*	3	24 gal	*	13,999
19SC	150 XR4	*	**179.09/120 mo**	19′9″	88″	24/12V	S.S.	*		*	3	36 gal	*	14,999
19SC	200 hp	*	**187.45/120 mo**	19′9″	88″	24/12V	S.S.	*		*	3	36 gal	*	15,699
QUICKFIRE DUAL CONSOLE TOURNAMENT RIGS Designed for you and your best fishing buddy.														
17DC	115 hp	*	**$170.21/ 84 mo**	16′10″	82″	24/12V	S.S.	*		*	3	24 gal	*	$11,699
18DC	115 hp	*	**155.21/120 mo**	18′	86″	24/12V	S.S.	*		*	3	24 gal	*	12,999
18DC	150 XR4	*	**171.93/120 mo**	18′	86″	24/12V	S.S.	*		*	3	24 gal	*	14,399
19DC	150 XR4	*	**182.67/120 mo**	19′9″	88″	24/12V	S.S.	*		*	3	36 gal	*	15,299
QUICKFIRE FLIPPIN' DECK RIGS The ultimate tournament rigs.														
18FD	150 XR4	*	**$179.09/120 mo**	18′	86″	24/12V	S.S.	*		*	3	(2) 15 gal	*	$14,999
19FD	150 XR4	*	**185.06/120 mo**	19′9″	88″	24/12V	S.S.	*		*	3	(2) 22 gal	*	15,499
19FD	200 hp	*	**189.84/120 mo**	19′9″	88″	24/12V	S.S.	*		*	3	(2) 22 gal	*	15,899
QUICKFIRE FISH & SKI RIGS No one has more for you and your family.														
16FS	90 hp	*	**$160.03/ 84 mo**	16′4″	76″	12V	S.S.	*		*	2	17 gal	*	$10,999
17FS	115 hp	*	**171.67/ 84 mo**	16′10″	82″	24/12V	S.S.	*		*	3	24 gal	*	11,799
18FS	115 hp	*	**155.21/120 mo**	18′	86″	24/12V	S.S.	*		*	3	24 gal	*	12,999
18FS	150 hp	*	**167.15/120 mo**	18′	86″	24/12V	S.S.	*		*	3	24 gal	*	13,999
19FS	150 hp	*	**179.09/120 mo**	19′9″	88″	24/12V	S.S.	*		*	3	36 gal	*	14,999

NOTE 1: Payments listed are for qualified buyers at participating MMAC financing Astro dealers and are based on 12.99% APR, 20% down (cash or trade) plus applicable taxes, licenses and fees. Specific monthly terms are noted. Ask your Astro dealer for complete details.

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NOTE 2: Suggested Retail Prices listed are for customers **East** of Rocky Mountains. Because of additional freight expense, prices are slightly higher west of Rockies.

† AL = aluminum S.S. = stainless steel

We are constantly striving to improve our boats and therefore must reserve the right to change specifications and prices without notice. Photographs may include optional equipment.

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Call 1-800-BOATS-90 for your nearest Astro fishing rig dealer.

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Science Newsfront

By ARTHUR FISHER

A powerful new scanning electron microscope at the University of Liverpool can inscribe volumes on the head of a pin.

Pinhead science

Forget about how many angels can dance on the head of a pin. Researchers at Britain's University of Liverpool have used a super-powerful scanning transmission electron microscope to show that they can punch a trillion tiny holes in a pinhead, or inscribe it with the entire contents of the *Encyclopedia Britannica*'s 29 volumes. The instrument is shown in the photo above. The block of text shown in the inset above is actually just one micron—a millionth of a meter—wide, with each dot less than 0.01 micron across. A million such dots equals the width of a pencil line.

"For possible data storage," Liverpool's Professor Colin Humphreys told European Correspondent David Scott, "this represents a density at least a thousand times greater than any existing computer system. Information could be coded as perforated patterns on metallic tape or discs, similar to the way music is written and then read on player-piano rolls. Because the holes are of molecular size, we could have microporous sieves and filters for use in chemistry and biotechnology, and even isolate viruses to advance medical science. Ultra-fast electronic circuits are another possibility."

For writing or pattern making, the electron beam is deflected by electrostatic plates, much the same way as in a TV picture tube. But with this microscope, Humphreys explained, the precision of aim needed is comparable to sitting in a geostationary satellite and trying to paint the window frame of a doll's house on Earth's surface 100 miles below with a single-bristle brush. Just how the intense beam drills such minute holes is still being researched, Humphreys says. "It may be a form of electron-stimulated desorption . . . but call it zapping if you like."

The electron microscope was built by two British companies, VG Microscopes and Link Analytical.

Quantum wires

Researchers at the University of California, Santa Barbara, have fashioned a novel material in which electrons act in a way that is radically different from their behavior in conventional materials. The material, which contains a matrix of wires so tiny that six million of them could fit in a human hair, may herald electronic devices with revolutionary properties in the 21st century.

The UCSB team was headed by Professor Pierre M. Petroff, who announced that the new material was the world's first quantum-wire superlattice, the most advanced of a new class of materials that contain so-called "quantum electronic structures."

A quantum-wire superlattice is a region in a semiconductor chip that contains millions of ultrafine wires so small that they force electrons to move in one direction only, along the wire's long axis. Quantum theory states that

Continued

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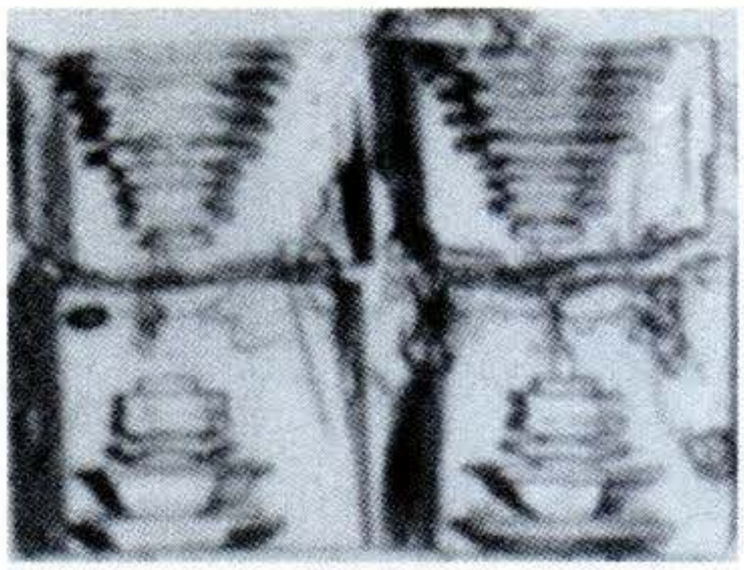
such electrons should encounter much less resistance than they would in normal wires and could therefore carry current more effectively.

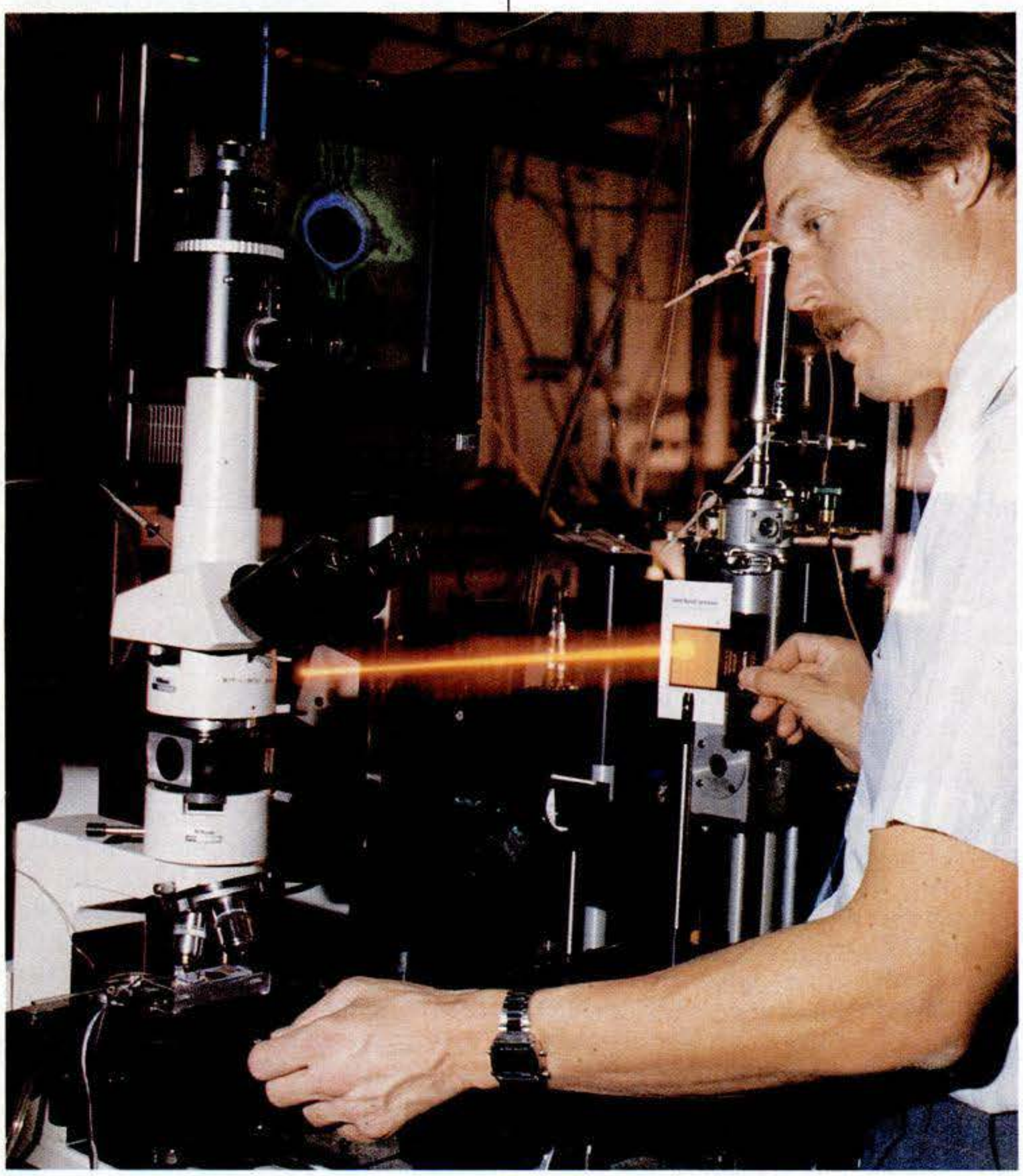
This phenomenon, electronics researchers conclude, could make it possible within a decade or two to build superchips that cram 100 times as much function in the same amount of space, while running 1,000 times faster and consuming considerably less power. The result could be to shrink a supercomputer to the size of a lap-top that could run on flashlight batteries.

Narrow-beam laser

A new type of semiconductor laser with significant advantages over conventional kinds is demonstrated in the photo below by Paul L. Gourley, head of the team of Sandia National Laboratories physicists that developed it. The microscopic laser is a custom-tailored single crystal with mirrors and lasing medium precisely grown layer by layer by the technique called molecular beam epitaxy. It emits laser light from its top surface, unlike conventional devices that are side emitting, and does so at room temperature with a continuous-wave beam that is highly efficient. The beam, made visible by an infrared-detector card in Gourley's right hand, is clearly circular and tightly focused. Researchers anticipate these advantages will be harnessed in applications ranging from optical computing to telecommunications.



Captured: Virtually identical snow crystals disprove the old saw.



Sandia's surface-emitting semiconductor laser has advantages over conventional types, including high power and a beam with little divergence.

No two alike?

Who has not been exposed to the explicit statement that the wondrous geometry of snowflakes is so varied that no two are alike?

Well, forget it. Nancy C. Knight, a meteorologist at the National Center for Atmospheric Research in Boulder, Colo., has the evidence to disprove that durable bit of folk wisdom. It is the photo that appears here, showing side by side two snow crystals that are virtually identical. The crystals were collected in a NASA cloud climatology experiment on a glass slide coated with oil and exposed at the end of a rod extended from an aircraft.

In her report on the observation in the Bulletin of the American Meteorological Society, Knight states: "In many years of snow-crystal collection, the author has seen no other examples of such crystals."

Finding the "disappeared"

During Argentina's so-called "dirty war" from 1976 to 1983, when human-rights violations by the right-wing military junta were rampant, more than 200 children were kidnapped, many of them infants. Some 150 of these "disappeared" remain missing. And because so much time has elapsed, it is increasingly difficult to identify the individuals who do surface and reunite them with their families.

Now a powerful tool of molecular biology has come into use to untangle the many problem cases. Geneticist Mary-Claire King of the University of California, Berkeley, explained the technique at a symposium on Defending Human Rights with Genetics and Forensic Evidence given in January in San Francisco.

The identification method relies on using mitochondrial DNA as a "fingerprint." Every child inherits from its mother a highly specific sequence of DNA that is found in the mitochondrion, a cell body that lies outside of and contains far less DNA than the nucleus. The genetic sequence is so specific that a child shares the exact pattern only with its mother and certain relatives on its mother's side, such as a maternal grandmother. Matching of mitochondrial DNA thus provides indisputable proof of a person's identity. Many grandparents and other relatives of kidnap victims have now stored their DNA profiles in the National Genetics Data Bank established by the Argentine government.

"Essentially," King says, "the ability to impersonate anyone is now over." PS

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WHY AMERICA'S HAVING A CHANGE OF HEART IN PICKUPS.

CHEVY SPORTSIDE. MORE V6 POWER THAN FORD, STYLED LIKE NO TRUCK AVAILABLE FROM FORD.

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That's how hot 'n juicy Chevy Sportside is. The swept-back looks alone can incite your glands to riot.

There's much more, of course. There's the standard Vortec V6. Bristling with fuel-injected aggressiveness. More standard half-ton power than Ford.

If you want even more force (and you might, you might) get the available 350 V8.

The Getrag-licensed 5-speed manual transmission with overdrive is standard. So is the sporty stepside box.

See the Chevy Sportside at your Chevy dealer's. In either 2- or 4-wheel drive. And you'll see why America's having a serious change of heart about ordinary-looking, outdated pickups.

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THE *Heartbeat* OF AMERICA TODAY'S CHEVY TRUCK™

Let's get it together...buckle up.

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Automotive Newsfront

By DAN McCOSH Detroit Editor *with Stuart F. Brown in Arizona, David Scott in England, and Brian Nadel and Richard L. Stepler in New York*

The all-wheel-drive Pontiac Stinger, shown recently at the North American International Auto Show, has pop-off panels to go from an enclosed coupe to an open-air sport utility. A pnuematic active suspension raises the vehicle four inches for off-road driving.

Picnic table to go

You might have to make extra room in your garage to accommodate Pontiac's Stinger concept car and its five removable glass panels. The car does a striptease until all that is left is an open-air off-road sports vehicle.

Stinger has a body made of carbon fiber and is powered by a three-liter four-cylinder 16-valve engine that develops 170 horsepower at 6,000 rpm.

The flexibility built into the Stinger, which was unveiled along with a host of other concept cars at the North American International Auto Show in Detroit (see "Show Stoppers," this issue), can be seen in its seating, which converts from form-fitting bucket seats to a bed to an elevated vantage point for viewing scenery or the occasional drive-in movie. The Stinger is also equipped with a lounge chair, pull-out radio, hand-held vacuum, camper stove, picnic table, and a cooler that pulls out of the front door, making this a 1990s dune buggy that is kind of a Swiss army knife on wheels.

Pontiac says that while the car appears futuristic, it is mass-producible. That claim is taken seriously these days because it was only two years ago that another far-out concept van made its debut: The General Motors APV van proved to be a dead ringer for the new line of minivans GM is preparing to introduce this fall.

Free-revving RX-7

While on a flat-out acceleration run at Phoenix Firebird Raceway in Arizona, the new Mazda RX-7 rotary engine topped out at 8,000 rpm. That was a quick demonstration of one of the major changes in the 1989 upgrade of Mazda's unique Wankel-engine-powered two-seater. The rotary engine now spins an extra 1,000 rpm in manual-transmission models, owing to lighter rotors and modifications to the intake system.

The non-turbocharged version of the RX-7's new engine gets a tuned intake manifold that uses the rotary valving of the Wankel to set up resonance pulses that alternate a pressure

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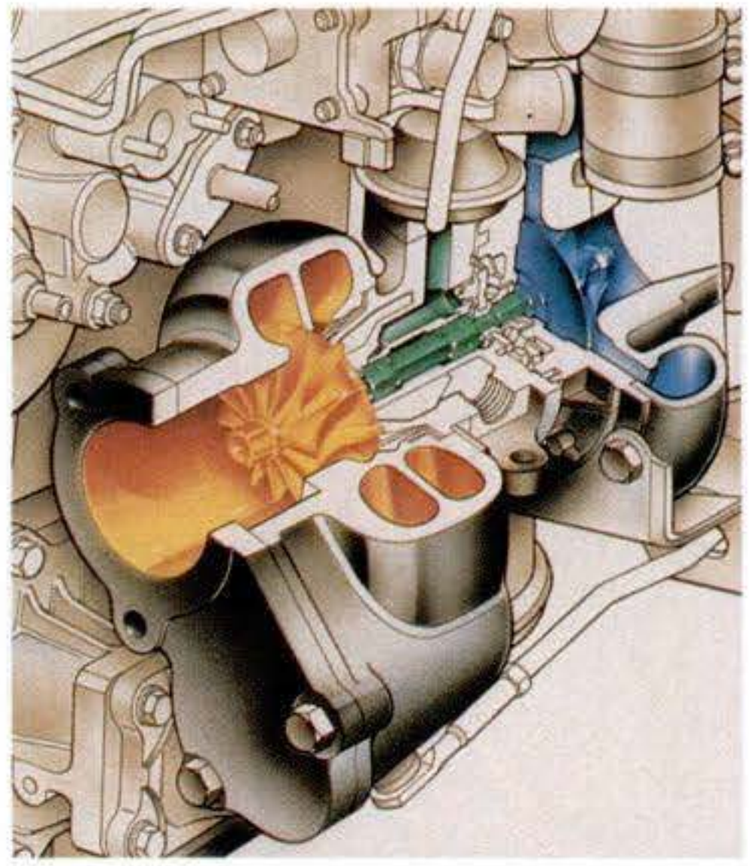

The Mazda RX-7 moves to more of a flat-out performance car with a refinement of the twin scroll turbocharger (right) to increase power to 200 hp.

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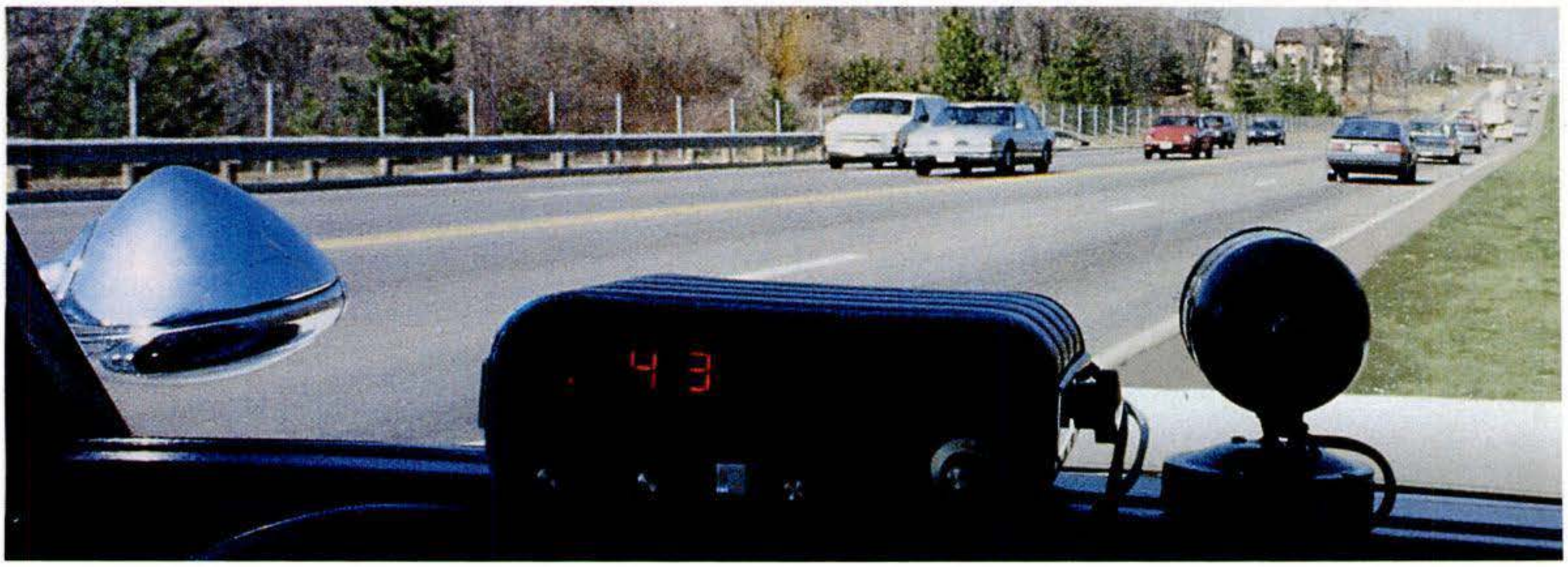

Traffic radar doesn't say which car is being clocked, it merely flashes a number. The radar operator must then try to determine which vehicle produced the reading.

Why radar makes mistakes. How to protect yourself.

Although nine different errors have been documented for traffic radar, the most common source of wrongful tickets is mistaken identity.

It's hard to believe, but traffic radar does not identify which vehicle is responsible for the speed being displayed. It shows only a speed number and nothing else. The radar operator must decide who is to blame.

How radar works

The radar gun is aimed at traffic and it transmits a beam of invisible radar waves. Each moving object within range reflects these invisible waves back to the radar gun. Using the Doppler principle, the radar calculates speed from the reflected waves.

Traffic radar is blind

Traffic radar works differently from military, air-traffic-control, and weather radars. The others use rotating dish antennas in order to track many objects simultaneously.

Traffic radar uses a far smaller, far cheaper, gun-shaped antenna. This simplification requires traffic radar to ignore all reflections but the strongest. The number displayed is speed calculated from the strongest reflection.

The best guess

Remember, these reflections are invisible. Truck reflections can be ten times stronger than car reflections. How can the operator know for sure which vehicle is responsible for the number?

The truth is, he can't be sure in many cases. The result is mistaken identity. You can be ticketed for somebody else's reflection.

Self defense

The only way to defend yourself against these wrongful tickets is to know when radar is operating near you. Others agree with this method. In his verdict upholding a citizen's right to use a radar detector, Judge Joseph Ryan, Superior Court, District of Columbia, wrote:

"If government seeks to use clandestine and furtive methods to monitor citizen actions, it can ill afford to complain should the citizen insist on a method to effect his right to know he is under such surveillance."

We can help

We specialize in radar warning. And Escort and Passport do far more than simply find radar. Upon radar contact, the alert lamp responds and the meter shows radar signal strength. At the same time, you will hear an audio warning —pulsing slowly when the radar is weak, quicker as it strengthens, then constant as you approach close range. When you know exactly how strong the radar waves are, you'll know when the radar unit is near enough to actually have you under surveillance.

Expert's Choice

Escort and Passport are the most effective radar-warning instruments available. But don't take our word for it. *Car and Driver, Popular Mechanics* and *Roundel* magazines have each published independent tests of radar detectors. And each gave us the highest ratings. Just call us toll-free and we'll send reprints of the complete tests, not just excerpts or quotes.

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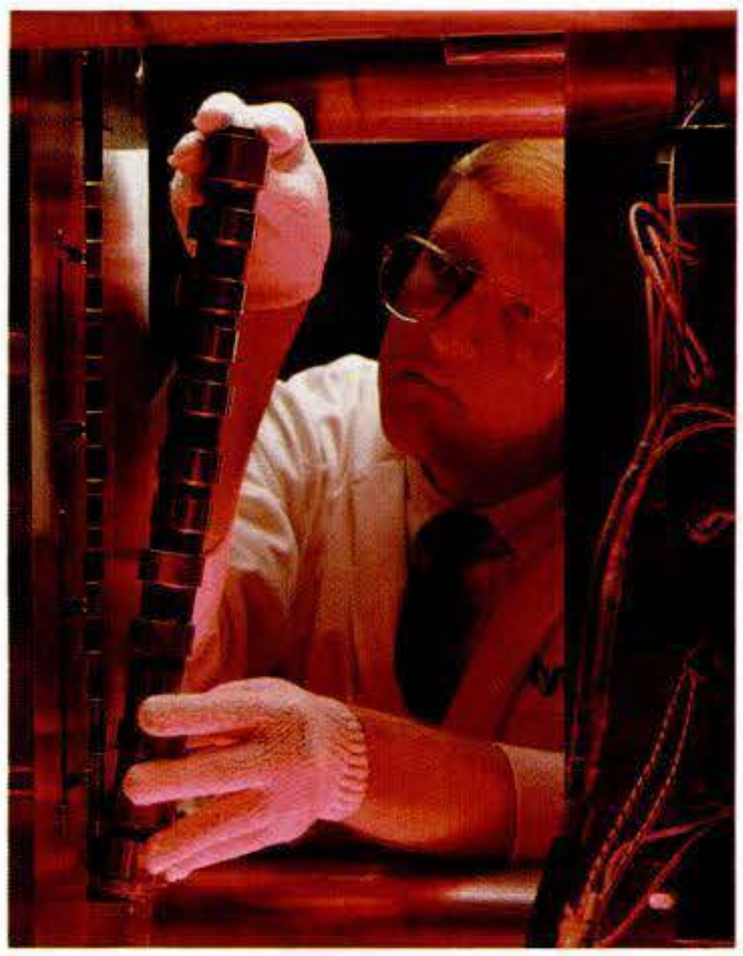
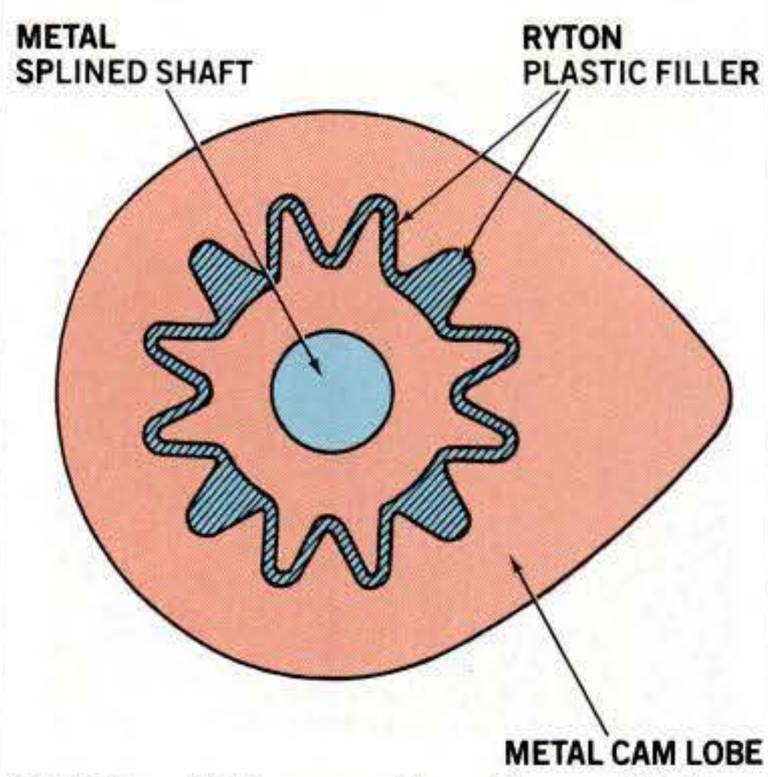


wave between the twin rotors. Power has been increased to 160 hp at 7,000 rpm, compared with 146 hp at 6,500 rpm for the 1988 model.

The parallel improvement in the turbocharged version is a more modern version of Mazda's twin-scroll turbo. The new engine uses a completely separate exhaust tract to supply pulses



Phillips 66 is experimenting with hybrid camshafts made from metal lobes bonded onto a splined metal rod with Ryton, an engineering plastic.

from each rotor independently to opposite sides of a power turbine. The result is improved throttle response for the turbo. The new turbocharger also uses electronics to control boost pressure.

The result of these modifications, along with a lightweight turbo rotor and increased compression ratio, is that the turbo-rotary engine is rated at 200 hp at 6,500 rpm, compared with 182 hp for the old model. The suspension, particularly the automatic toe-in feature Mazda introduced two years ago, is unchanged, so the RX-7 remains solid and controllable.

Mazda is upgrading the RX-7 lineup as a prelude to the midyear introduction of a smaller, conventional-engine roadster to be called MX-5 Miata. The aim is to make the venerable rotary-powered sports car into more of a flat-out performance car. Judging from a short test drive, the refinements enhance the engine's flexibility and add to its overall performance. The new RX-7 is now a more muscular car, which is likely to please most drivers, but that added excitement comes at the expense of some ease of shifting in the manual-transmission version.

Lighter camshafts

Inventor Royce Husted ["One Thumb, 15-Speed Shift," July '85] has developed a process for injecting a Phillips 66 plastic into a cavity inside a camshaft. (See the illustration

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on the left.) The resulting metal-plastic composite shafts weigh and cost 50 percent less than all-steel ones do and run more quietly, Phillips says. Endurance testing is planned in a production twin-cam engine.

High-tech stop lamp

Pontiac will begin using a center stop lamp based on holographic film. The film forms an etched lens that concentrates light from a source in the roof so that it is visible from the rear of the car as a bright red circle of light in the center of the rear window.

The new light system, which was developed jointly by GM Hughes Electronics and Pontiac, promises to be easier to clean and should obstruct less of the driver's rear field of view. It is also the first automotive application of holographic film—a material system that has been appraised recently for head-up displays.

The first car to get the new lamp will be a special-edition Grand Am SE, which also will sport a new high-output version of GM's Quad 4 2.3-liter four-cylinder engine.

PHOTO BY STUART F. BROWN

Nissan Axxess blends a small station wagon with a car and comes with either front-wheel or four-wheel drive. Power is provided by a 2.4-liter engine.

Sport van

Cross a small station wagon with a minivan and you get Nissan's atrociously spelled but nice-looking Axxess. The vehicle is a hybrid designed to appeal to families who are willing to try something in between the traditional two categories of vehicles.

The Axxess is powered by a slightly detuned version of the 2.4-liter four-cylinder engine in Nissan's delightful

Continued

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The Chevrolet "Street" Camaro struts its stuff. The car has become a rolling test bed for a line of high-performance aftermarket parts, like the fiberglass hood with air scoop and extra-wide wheels.

PHOTO BY HIDDEN IMAGE

The 1990 Hyundai Excel is caught in the open during road testing. Although its size is unchanged, the Excel's body gets a smoother, more rounded look.

240SX sports coupe. With 138 hp and nearly 150 pound-feet of torque, the transverse-mounted engine has respectable acceleration and hill-climbing ability, even coupled to the optional four-speed automatic transmission. A five-speed manual gearbox is standard.

Handling is more carlike than vanlike, with good steering and cornering feel, although some road shock is transmitted to the cabin. The vast, sharply raked windshield provides an excellent view of the road over the sloping nose. The driver must strain, however, to peer over the end of the hood. This can make tight parking maneuvers a matter of intuition. Access (pardon the pun) to the interior is good through a pair of side sliding doors and a rear hatch. An optional seven-passenger seating package can be had, but be warned: Those last two passengers had better be children or small pets.

The base-model Axxess has front drive, but there's an all-wheel-drive version that varies torque delivery from front to rear as needed through a viscous coupling in the center differential. All of this hardware works well together, making Axxess sure-footed on ice and snow, as well as on dirt roads. The four-wheel-drive model has an EPA combined city-highway fuel-economy rating of 22 mpg; the front-drive version gets another two mpg.

POPULAR SCIENCE will test the Axxess in an upcoming car test.

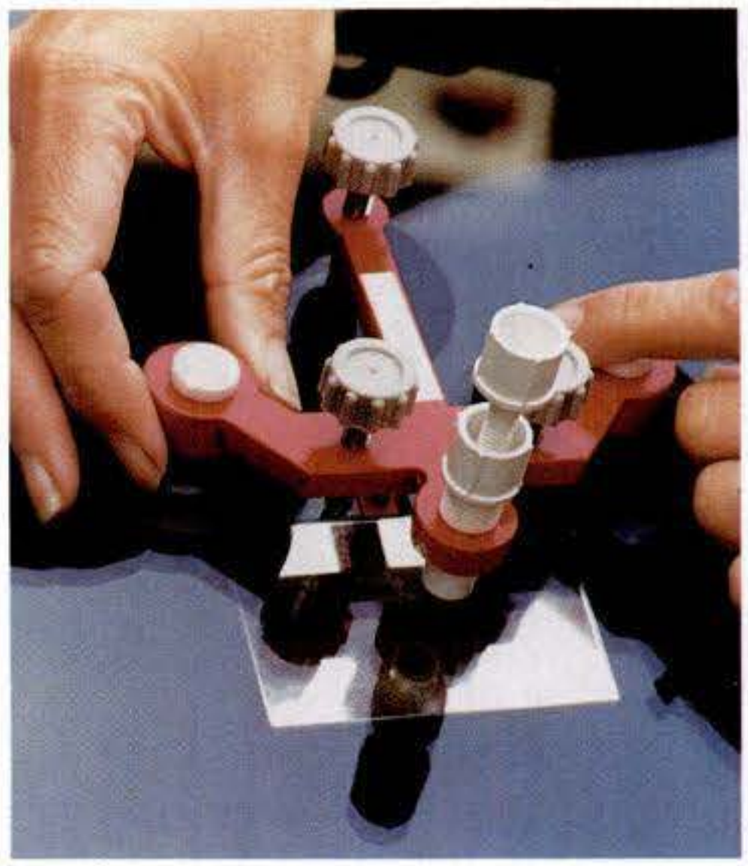
Crystal-clear repairs

Stone-damaged windshields can be repaired in less than 30 minutes with a kit that prevents further cracks, says maker Esprit Marketing of West Sussex, England. Using a suction-cup jig called a bridge, air is extracted from the damaged area, and polymer resin is injected into cracks and cavities. The resin is cured by ultraviolet light, chemically bonding it with the glass for a permanent seal. A polishing with fine abrasive paste completes the windshield repair.

Meanwhile, back in the United States, a similar system developed by Star Technology Windshield Repair can handle chips and cracks up to eight inches long, according to William Costello of the Boulder, Colo.-based company. He calls the process ADP—alternating dynamic pressure: Vacuum is alternated with pulsed injections of the resin under pressure, both to remove all air from the damaged area and to fill it uniformly. Costello says there is a catalyst in the resin so that it can cure to a clear polymer in three hours in normal sunlight. He adds that the disadvantages of UV-cured windshield products are that repairs can't be made on cloudy days and it's possible the repairs will haze over time. The Star system is portable, so repairs can be done at the car owner's house, while he waits.

News briefs

- Ford, Chrysler, and General Motors are teaming up to investigate the future use of plastic composite materials. The reason for forming the joint venture is to accumulate general knowledge on composites and standardize test procedures.
- Mazda, which is partially owned by Ford, will begin selling a slightly modified Ford sport utility vehicle, rumored to be the Bronco II. Mazda officials say this is the beginning of a more "reciprocal" relationship between the two car giants.
- Chrysler has announced that it will develop a mini sport-utility vehicle in a joint venture with Renault. Code-named "JJ," the four-wheel-drive vehicle would be built using a unique modular construction system and employ new materials for substantial weight savings. It will be built in factories in both North America and Europe. The price for a "nice unit, not an el strippo," says Chrysler Chairman Lee Iacocca, will be less than $10,000. PS



Three-part resin is cured in ultraviolet light to bond with glass to repair damaged windshields permanently in one half-hour, claims the maker.

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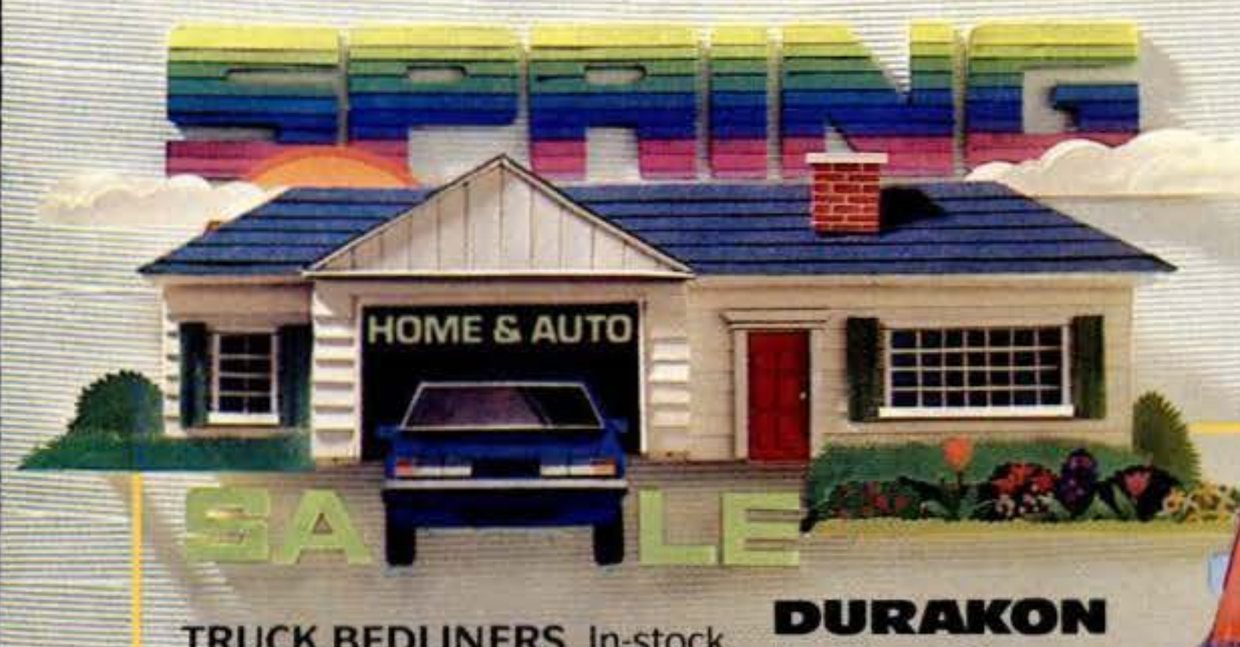

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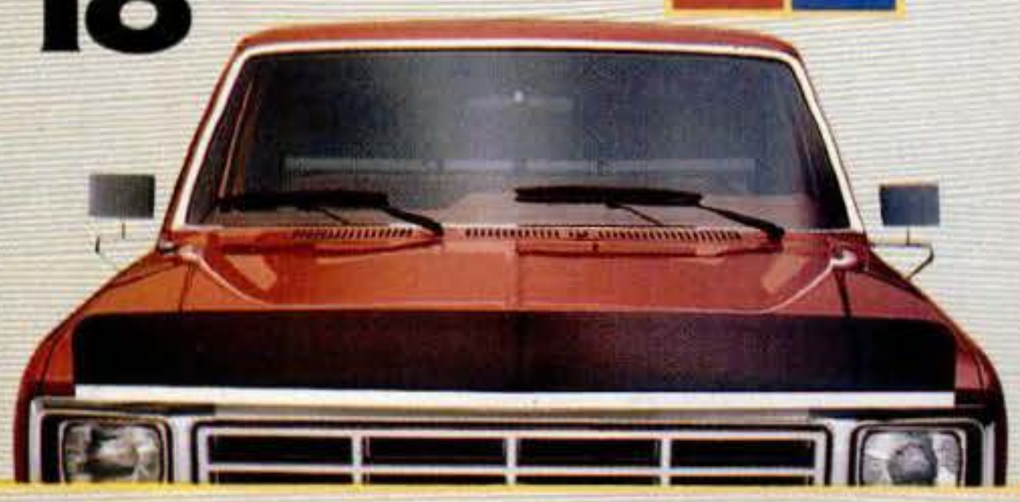

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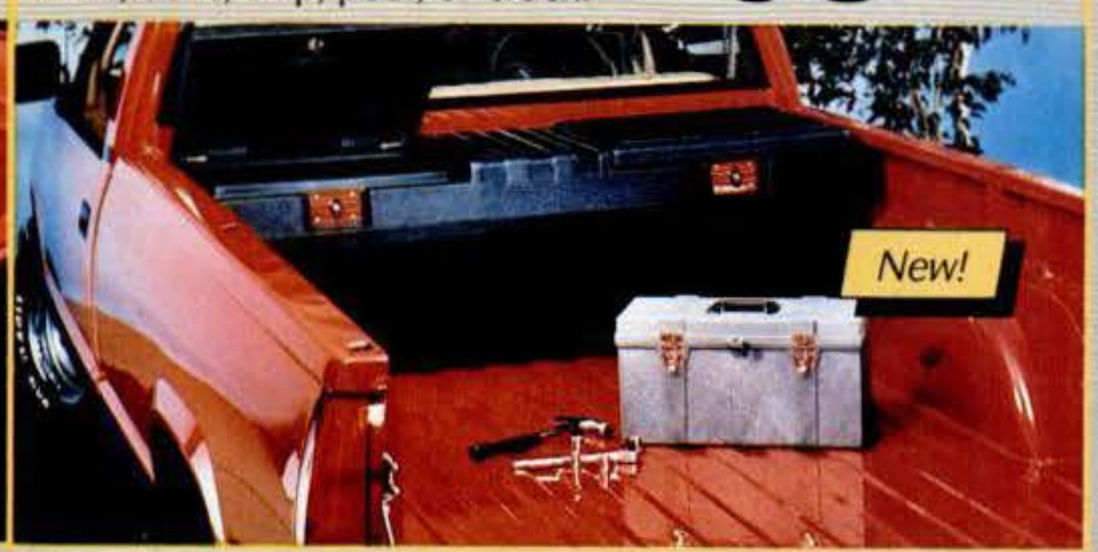

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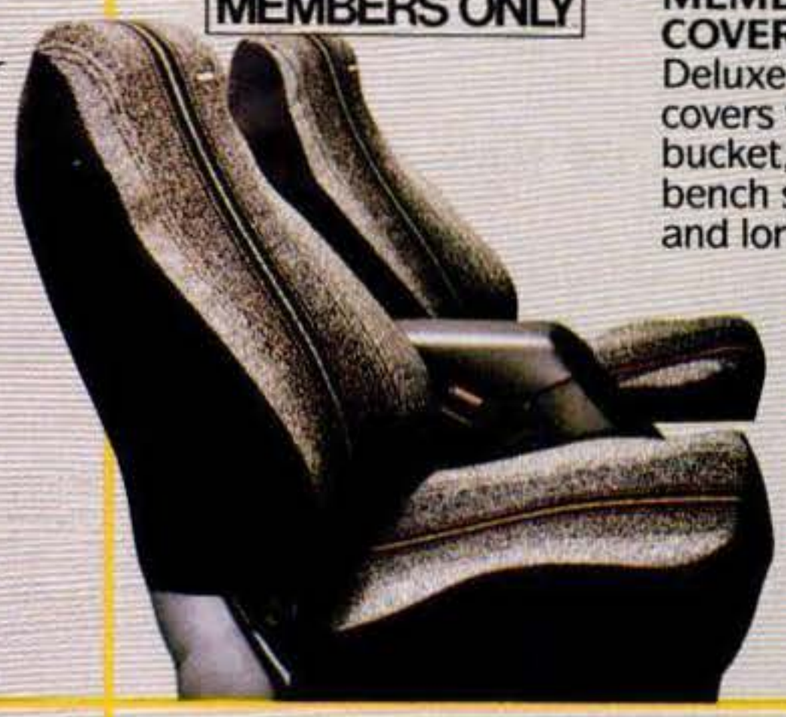

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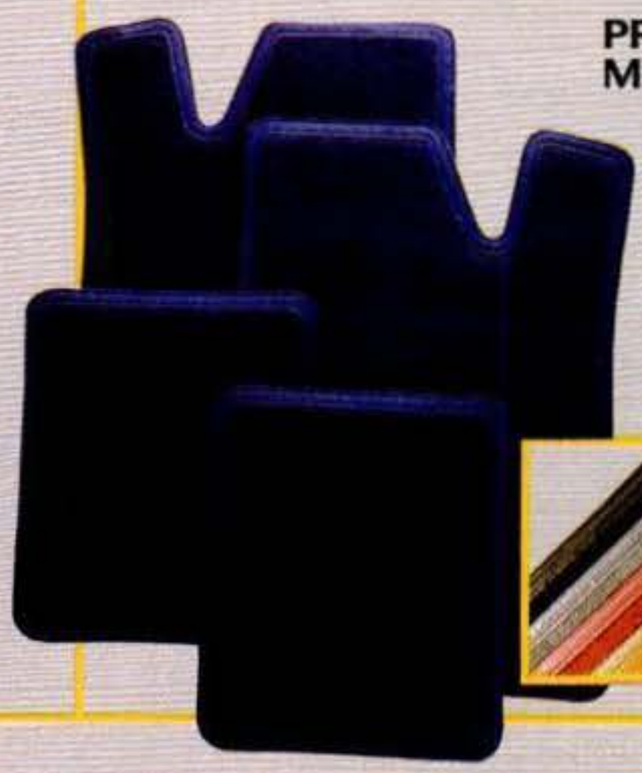

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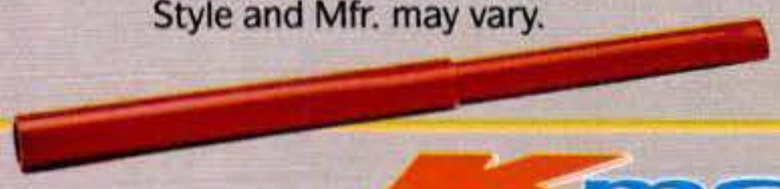

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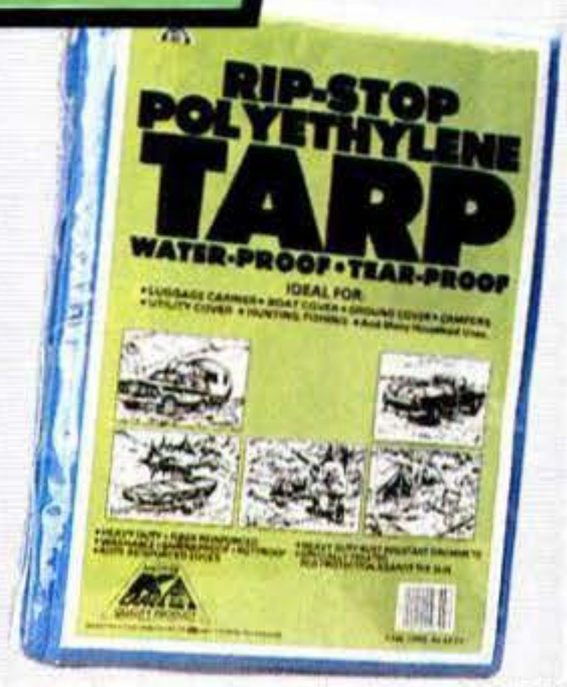

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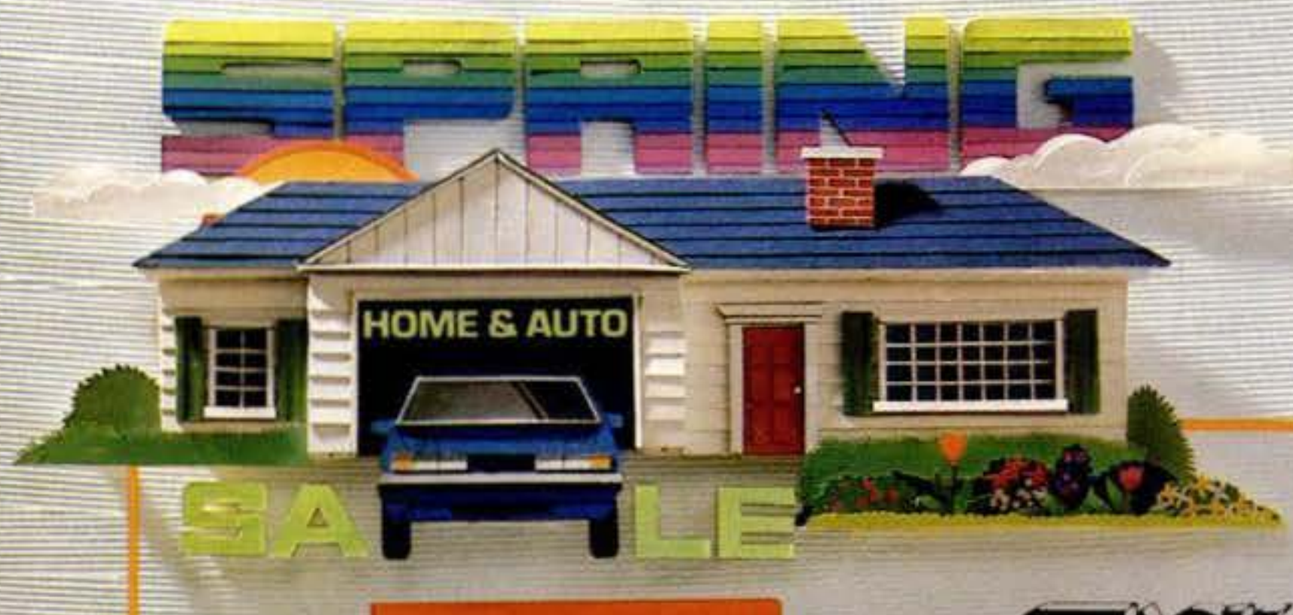

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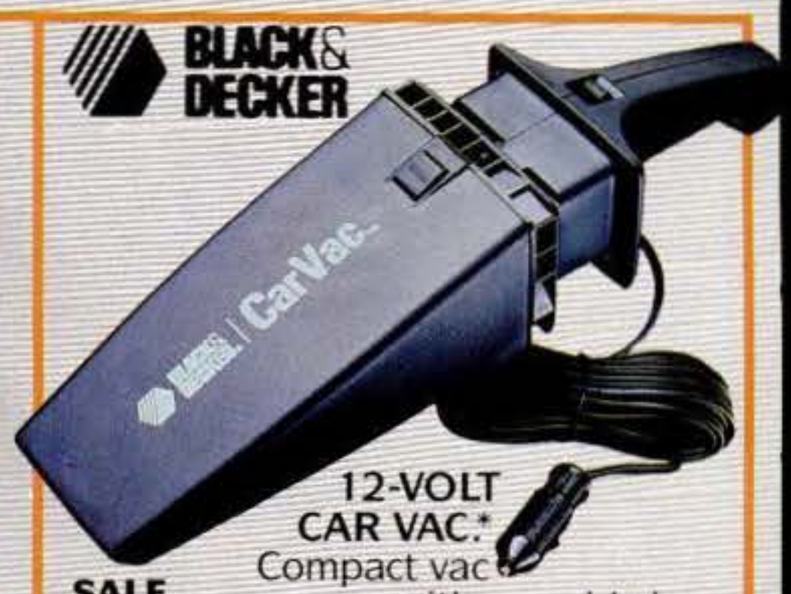

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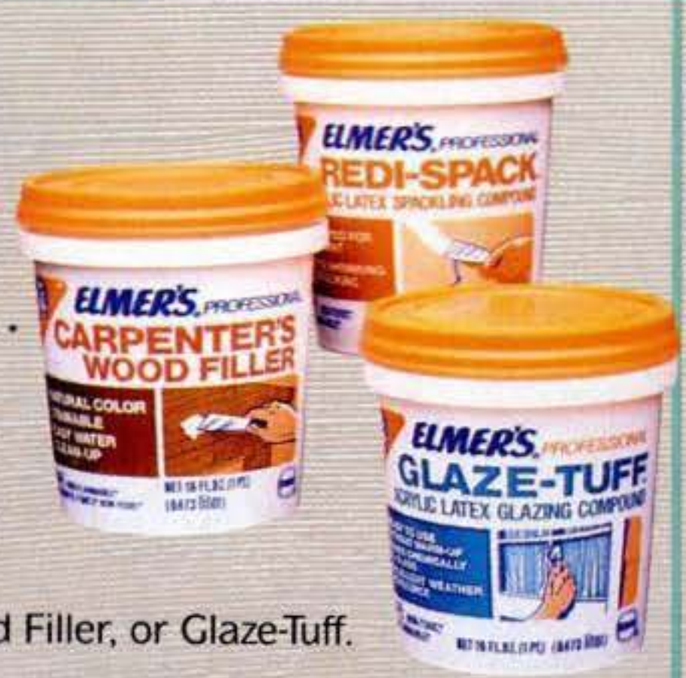

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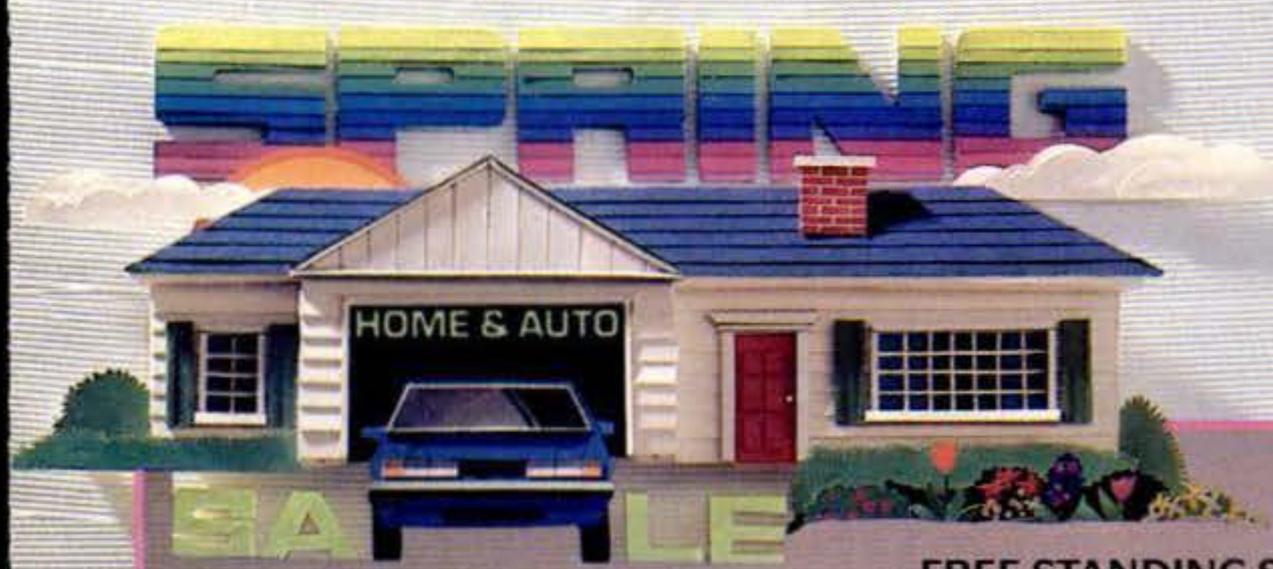

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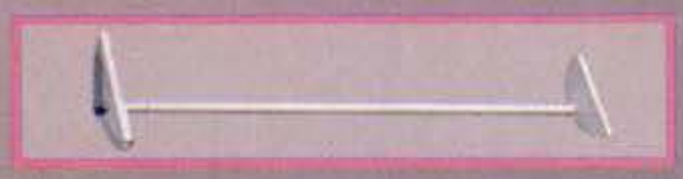

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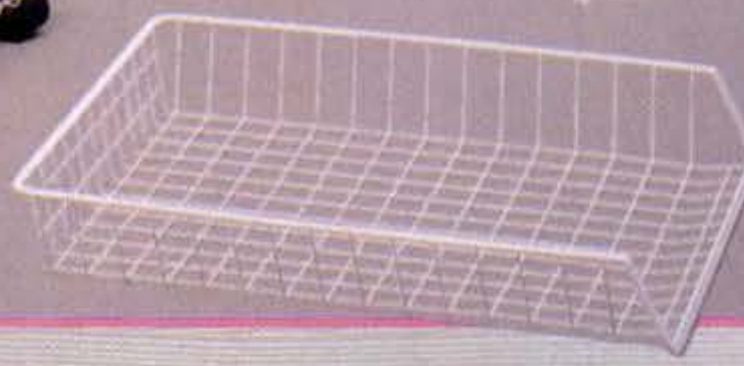

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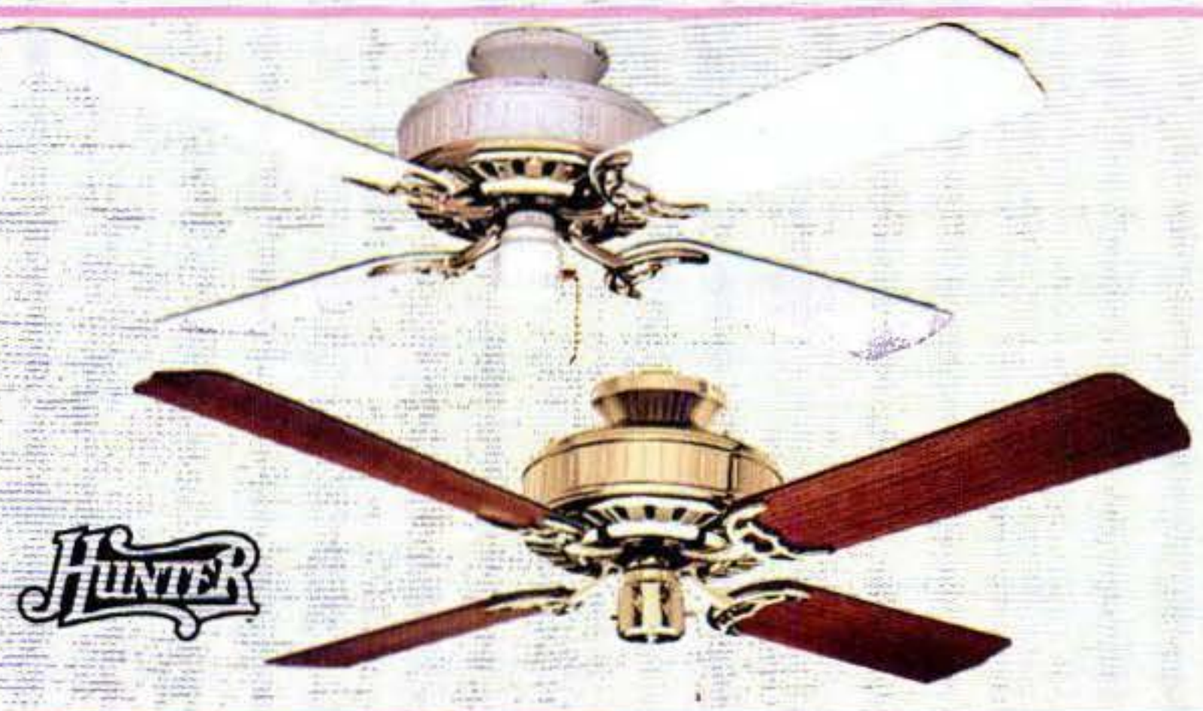

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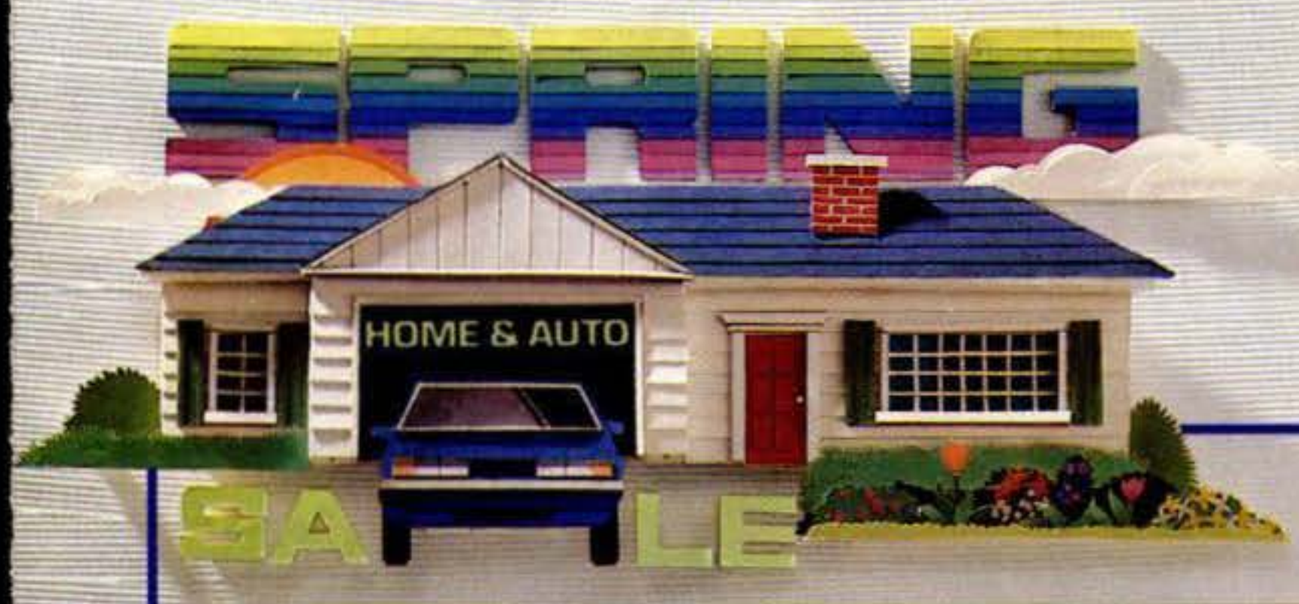

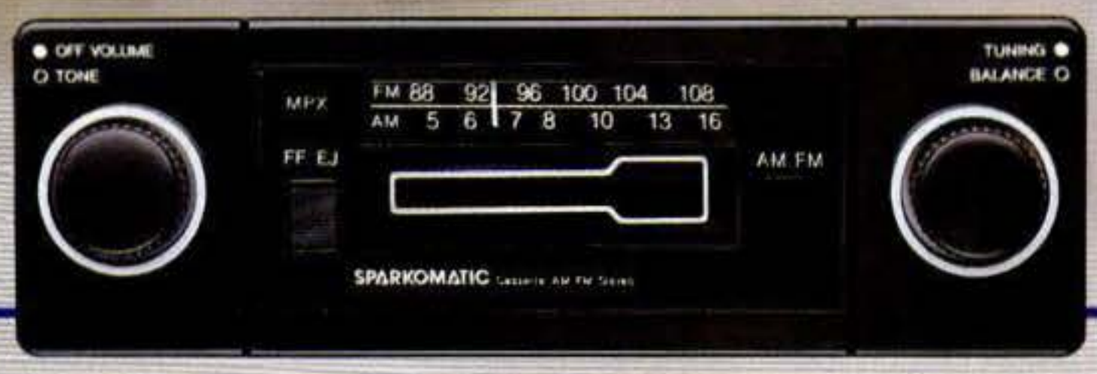

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Holey concrete!

You've just stepped onto a flat concrete parking lot after a heavy rain. But your shoes stay dry—and there's not even a puddle in sight. Why? Because the parking lot is made with porous concrete.

"Porous parking lots are the most popular application for our porous-concrete products," says David Harding, former director of technical support at Western Utility Contractors in Pleasant Grove, Utah. "We think porous wherever a customer needs a parking lot and there's a potential of excess water.

"With regular concrete," Harding says, "the object is to make a solid volume by mixing aggregate—bits of chopped rocks in various sizes—with a mortar paste made with cement, sand, and water." The mixing continues until the empty spaces caused by the rock gradations are filled.

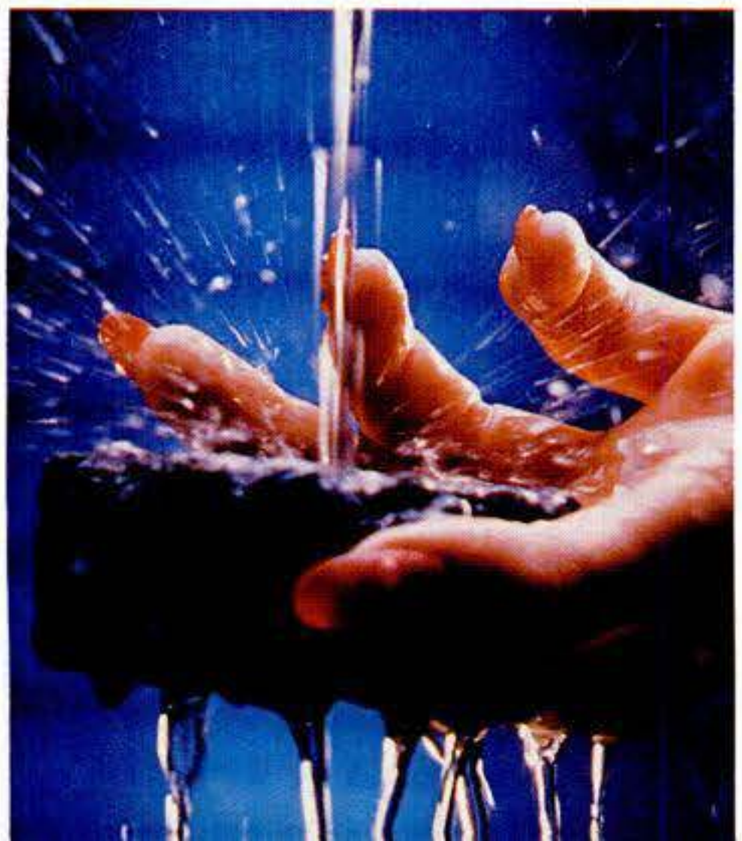
Porous concrete, however, is produced with uniform rocks and less paste. "We use only enough mortar to coat each rock," says Harding. "Instead of a solid, we're left with intentional voids."

These empty spaces allow water to percolate through the porous concrete faster than rain can accumulate on its surface. "There's no runoff except in a five-inch-per-hour situation," says Harding. "In a hurricane you'd have runoff, but that's about it.

"Porous parking lots also allow for a free flow of ground water," says Harding, "and that means that nearby trees, shrubs, and grass get watered evenly." With porous concrete, one inch of rain can be stored in the pavement, Harding claims. Without such storage, puddles aren't the only consequence on large regular-concrete surfaces: "Excess standing water and big runoffs can cause serious erosion or even sinkholes to form," Harding says.

Porous concrete compares favorably with regular concrete in strength tests. It also cracks less than asphalt or regular concrete if the air temperature remains fairly constant. "It's less durable where frequent freezes and thaws occur," Harding admits. While that limits its use in many areas, if researchers can solve the durability problem, porous parking lots should be soaking up puddles throughout the United States.—*Gode Davis*

Concrete slab lets water percolate through because it's made with voids in its structure. The porosity minimizes puddle formation in parking lots.



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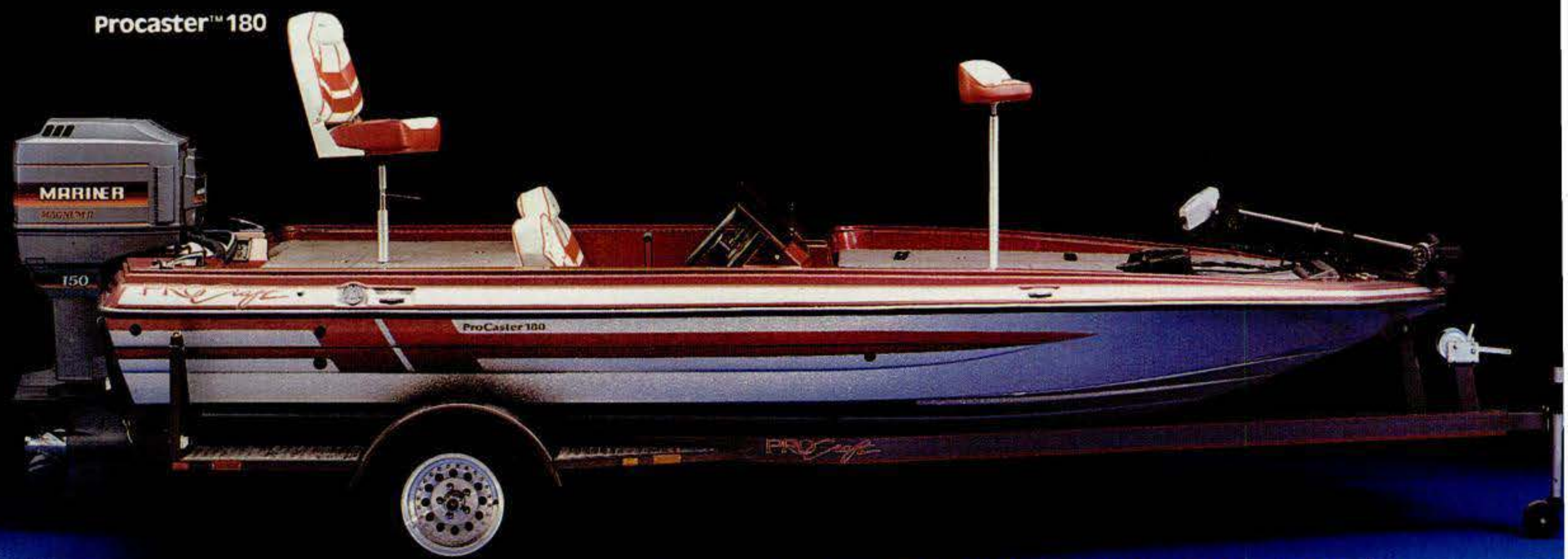
Procraft. The Beginning

Procaster™ 180



Procraft Performance Bass Models. Starting at $127.89 per month.[1]

Bass Hunter™ 1773

Procraft Aluminum Fishing Models. Starting at $101.70 per month.[1]

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Procraft Pontoon Models. Starting at $101.55 per month.[1]

[1] Based on Manufacturer's Suggested Retail Price of $6,990.00 (Bass Hunter 1673), $8,790.00 (Stalker 150) and $6,980.00 (Fishchaser 20), with approved credit at participating MMAC financing dealers. Payments based upon down payment of 20% (cash or trade) plus taxes, license and fees; 12.99% APR. Procraft dealer can provide additional details. Term is 84 months. We reserve the right to change prices and specifications without notice. Photos may include optional equipment.

* Limited warranty. Warranty details available at local Procraft dealer.

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Of A Great Fish Story.

If you're a fisherman, chances are you've thought about buying a fishing rig. And chances are, there are two concerns that have kept you from buying one: One, the cost. And two, the hassle of matching a boat with the proper outboard and then selecting all the right equipment and accessories you need.

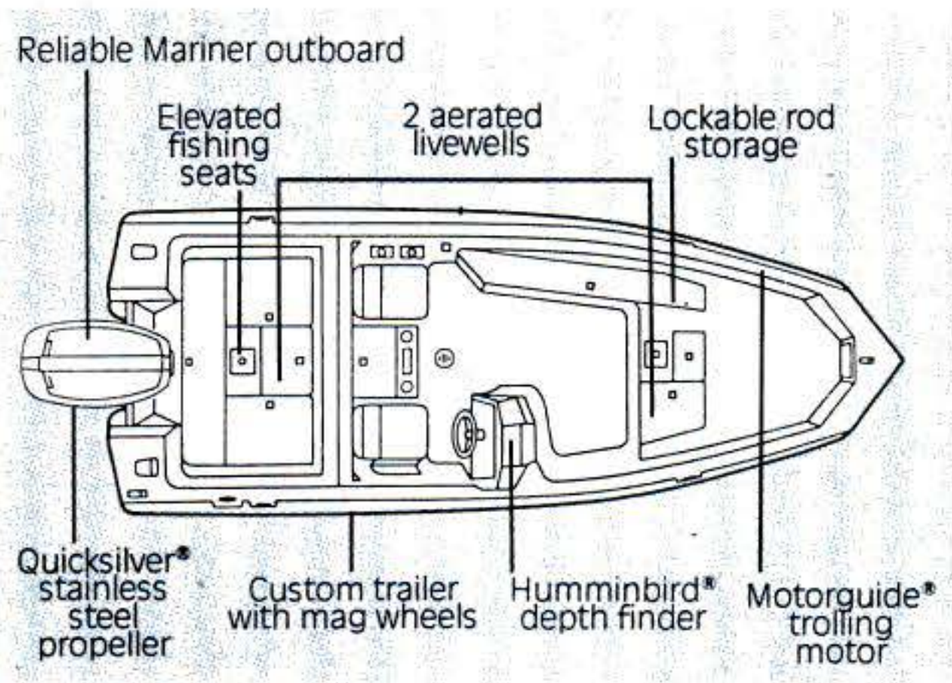
Procraft,® a new line of fishing rigs from the Mercury Powerboat Division of Mercury Marine, is out to change all that.

You see, before we even thought about putting a boat package together, we talked to the leading experts in the marine industry and spent hundreds of hours talking to thousands of people just like you.

And we did it all with one intention in mind: To find out what you're really looking for in a boat package, so we could design and build it for you.

And the results? A line of 48 top quality fishing rigs designed to fit a broad range of needs and budgets.

But more importantly, a line of fishing rigs so completely rigged and equipped that all you have to do is fill up the gas tank before heading out to your favorite fishing hole.



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No matter what you want to do on the water, we've got a boat for you:

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And an extensive line of aluminum models for all types of fishing, including our smaller Outdoorsman™ series and our bigger, more powerful Bass Hunter™ and Crappie Hunter™ series.

Each one is loaded with the features and accessories fishermen want—including a custom-matched Mariner outboard, the outboard known for outstanding reliability.

We cover everything from stem to stern.

Every Procraft is backed by the Procraft Stem-to-Stern™ warranty* that covers virtually every part on every boat, motor, trailer and accessory.

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Finally, boat service that isn't a lot of lip service.

Beyond all this, we're also introducing ProCare,™ a customer care program that's committed to giving you everything you need to keep you and your boat happy.

It all starts when you select your Procraft. Your dealer will offer you quick, on-the-spot financing, and give your rig a thorough inspection before you take it home. He'll also tell you everything you need to know about maintaining and running it safely. Plus, if you ever have a problem with your rig, you can be sure their certified service technicians will fix it properly and quickly.

So, if you've been holding out for the day when boating would be easy and affordable, welcome to that day. For the name of the Procraft dealer near you, and free product information, call: **1-800-526-6630.**

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There's a pair of brand-new players in the sports-coupe game, the Diamond-Star twins: Mitsubishi Eclipse and Plymouth Laser. Just how good are these eagerly awaited Japanese-American fun machines? To find out, POPULAR SCIENCE pits both a turbo and a non-turbo model against the benchmark Mustang GT and the Isuzu Impulse Turbo GT, which sports a Lotus-developed suspension. The new kids on the block indeed turn out to be diamonds—in the rough.

POWER GOOD

By DAN McCOSH
Detroit Editor

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PHOTO BY JOHN B. CARNETT

Four quick coupes (clockwise from foreground): Plymouth Laser RS, Isuzu Impulse Turbo GT, Mitsubishi Eclipse GS DOHC Turbo, and Ford Mustang GT.

The latest challenge to the once preeminent American-muscle-car establishment of V8-powered rear-drive sports coupes comes in the form of an amalgam of Japanese engineering combined with American styling. This meeting of East and West has produced the Plymouth Laser and Mitsubishi Eclipse—the first cars to roll out of the new Normal, Ill., assembly plant, operated by the Diamond-Star Motors Corp., jointly owned by Chrysler and Japan's Mitsubishi.

The Mitsubishi and Plymouth that came from this new alliance are virtually identical and offer the same powerplant lineup. The most powerful version of the front-wheel-drive Laser/Eclipse takes on the rear-drive sport-coupe power elite with a 190-horsepower intercooled-turbocharged-engine option that stretches the limits of power-handling capability for front-wheel drives. It's also available in a more sedate form, including a 1.8-liter base engine and a two-liter four-valve-per-cylinder unit. The POPULAR SCIENCE team tested two extremes of these 1990 models—a turbocharged two-liter five-speed-equipped Mitsubishi Eclipse GS DOHC Turbo and a non-turbo two-liter Plymouth Laser RS with a four-speed electronic automatic transaxle. To represent the rear-drive tradition we selected a 1989 five-liter V8-powered Ford Mustang GT, while the dark horse was the 1989 Isuzu Impulse Turbo GT.

It quickly became apparent that the distinguishing feature setting the character of these cars apart was power—how much, how it was generated, and how the chassis applied it to the road and to the seat of your pants.

Potent power plant

The shapely hood of the Laser/Eclipse is enough of an eye-catcher that it tends to detract from what's underneath—one of the most powerful two-liter four-cylinder engines in production today. In its most basic form the dual-overhead-cam engine with multi-port fuel-injection produces 135 hp at 6,000 rpm and 125 pound-feet of torque at 5,000 rpm. This gives it a specific output of nearly 68 hp per liter, slightly edging out General Motors' famed Quad 4 engine in power per displacement even before it is turbocharged. Without a turbo it is just 10 hp short of the turbocharged 2.2-liter engine used on both the Mazda MX-6 Turbo and the Ford Probe GT ["6 Quick Coupes," Sept. '88].

The four-valve-per-cylinder head and low internal friction contribute to the engine's spectacular performance. The

Continued

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GROUND ATTACK.

DODGE RAM PICKUPS.

Dodge pickups will take you by storm. Leading the charge is fuel-injection on every engine we make, even our monster 360 V-8. And behind it all is up to 5,500 lbs. of available payload, up to 11,000 lbs. of available towing and our exclusive 7 yr. or 70,000 mi. Protection Plan.† We've even added new anti-lock rear brakes. 1989 Dodge Ram Pickups. Hot on your trail.* 7/70

*When properly equipped. Reduced by passenger/option/cargo weight. †See this powertrain limited warranty & its restrictions at dealer.

BUCKLE UP FOR SAFETY.

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The Laser/Eclipse siblings (top) present identical instruments and controls in a handsome, ergonomically designed console. The Mustang (below) features an uncluttered, easy-to-read instrument panel with a large speedometer and tachometer. The pod to the right of the Impulse's steering wheel (bottom) puts heater controls within reach of the driver's fingertips.

PHOTO BY JOHN B. CARNETT

Mitsubishi motor uses needle bearings on the roller cam followers to reduce friction, and the spacing of its dual-overhead camshafts allows a 60-degree angle between the four valves. It's extremely smooth because of Mitsubishi's patented pair of counterrotating balance shafts. One shaft on each side of the block spins at twice the engine's speed, but in the opposite direction of the crankshaft—reducing secondary shaking forces and rocking moments common on in-line four-cylinder engines.

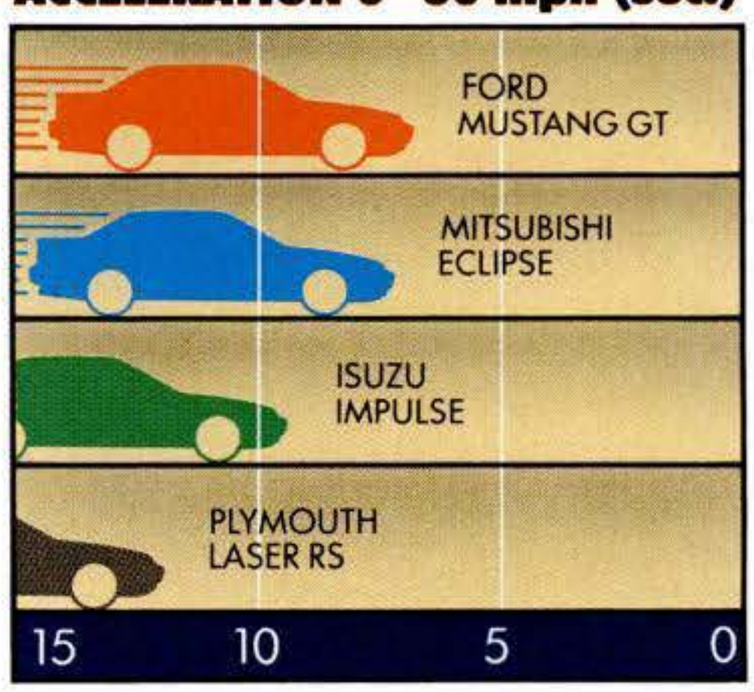
But the optional intercooled turbocharged engine is a fire-breathing monster, pumping out 190 hp, or 95 hp per liter—coming close to the magical 100-hp-per-liter output of a flat-out racing engine. An arm-twisting 203 lb.-ft. of torque at 3,000 rpm caps off the performance picture.

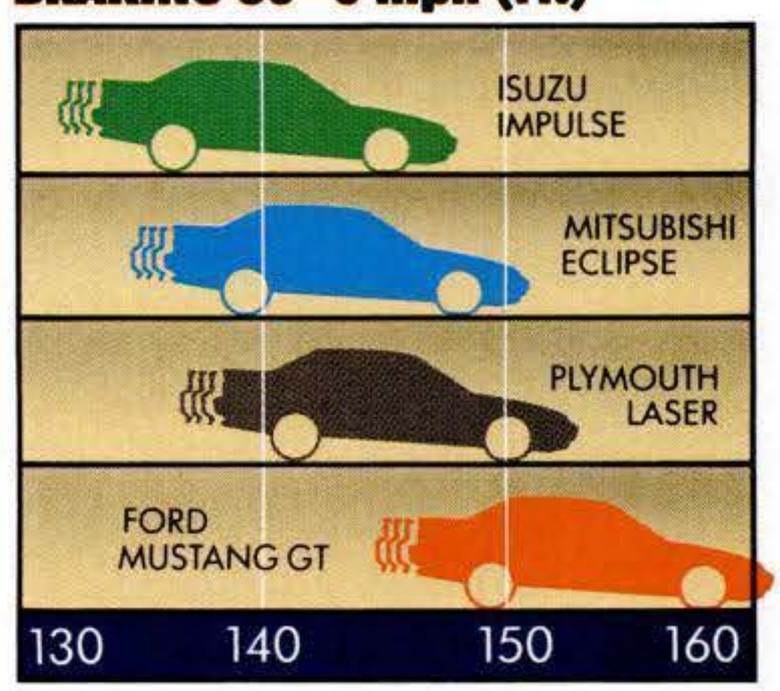
The drawback to all this horsepower is that the torque peak of the Mitsubishi engine comes at higher engine speeds than where many engines top out altogether. The high-revving nature of the engine ultimately proved to be one of the more troublesome features of the car. More about that later.

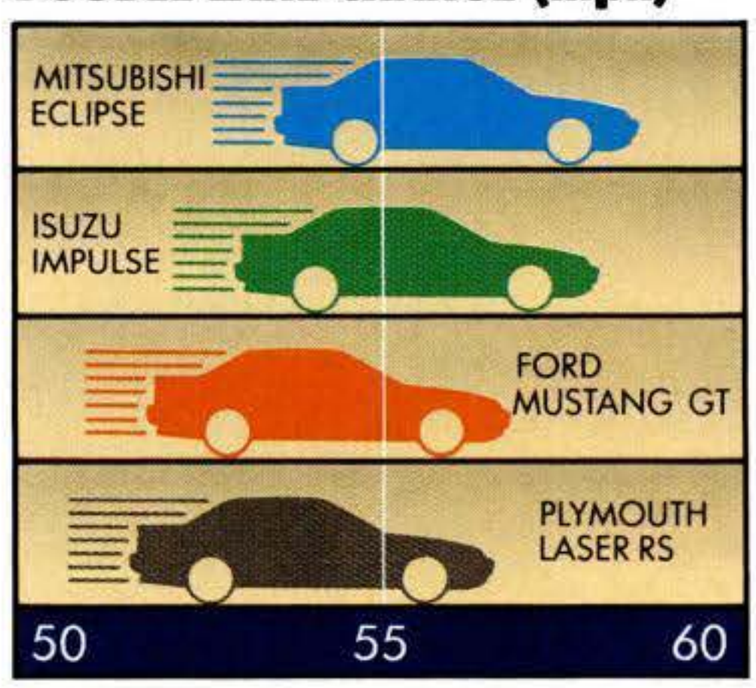
The Mitsubishi-designed engine's potency is contrasted by the comparative sluggishness of the single-overhead-cam two-liter unit in the Isuzu Impulse. The engine's output of 140 hp at 5,400 rpm and 166 lb.-ft. at 3,000 rpm comes despite an intercooled turbocharger. This is in part because the Impulse breathes through half as many valves as the Mitsubishi four cylinder.

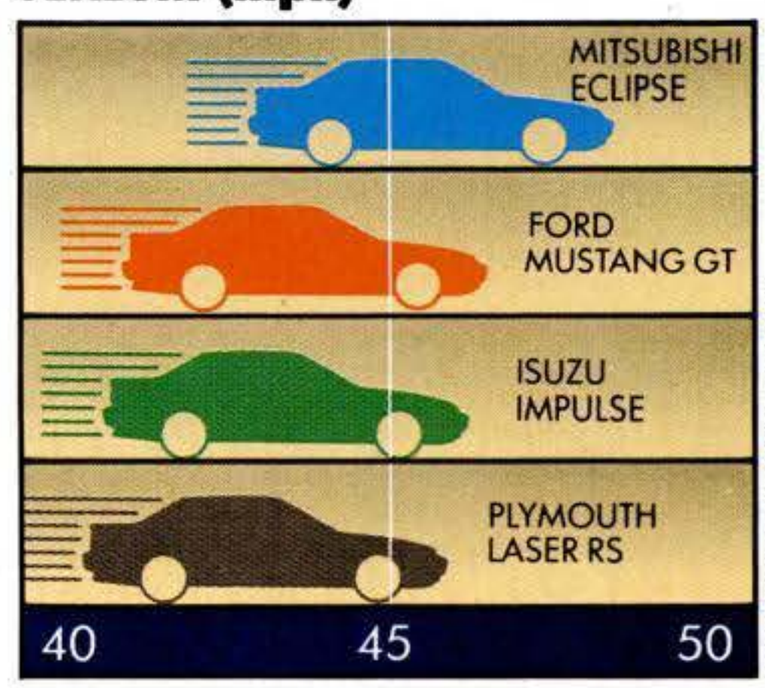
Even more of an outsider compared with the high-revving trio is the lumbering Ford five-liter V8, which coasts along at 225 hp at a sedate 4,200 rpm with 300 lb.-ft. of torque available at 3,200 rpm—effectively beating both the Impulse and Diamond-Star duo for torque production at barely over idle speed. Roller lifters, tuned induction, and sequential multi-port fuel injection were added in recent years; otherwise it's the same powerful, smooth-running V8 that harks back to the 1960s.

Raw power quickly separated the









ILLUSTRATIONS BY MITCHELL J. ALBALA

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coupe quartet on acceleration runs. The Mustang with its crisp-shifting gearbox smoked to a 0-to-60-mph time of 6.7 seconds. That edged out the Eclipse Turbo's 7.1-second run, while both cars were handily ahead of the Impulse at 9.3 seconds and the Laser at 11.8. (See table on next page for a comparison with other coupes we've tested.)

But there was more to the story than the numbers might indicate. Hard acceleration produced a disconcerting front-end wander in the Eclipse as weight transfer unloaded the front wheels. The sensation was distinct from the tendency of some cars to torque steer in a constant direction when power is applied, as exhibited by many high-powered front-drive cars we've tested recently, including the other Japanese-American sports-coupe couple, the Ford Probe and Mazda MX-6.

Smooth operator

The Laser, while always tractable, seemed to suffer from a mismatch between the free-revving engine and the automatic transmission in the lower gears. The result was less than invigorating performance off the line that improved dramatically as the revs built up.

The Mitsubishi-made automatic transmission features a lockout button on the shift column that keeps the overdrive from engaging; a second button on the console controls the shift points. The combination of driver inputs means you can give as many orders to your car's transmission as you can to a team of dogs. But the impact was noticeable only after the car reached cruising speed. In our test, the automatic-transmission Laser zipped from 30 to 50 mph in six seconds, a solid performance.

Differences in power output and torque band affected handling as well as acceleration. The peaky high-output turbo engine of the Eclipse could quickly push the car's front end wide while cornering, sometimes making it a handful to keep under control in tight maneuvers. At the other extreme, smooth, even power delivery from the Mustang V8 made throttle steering almost second nature. While the Impulse benefited from the predictability of its rear-drive layout, its engine had neither the low-end torque nor the power of the Mustang.

Suspension differences also resulted in substantial differences in handling characteristics. Both the Eclipse and Laser rely on a basic MacPherson-strut front suspension and a twisting-beam solid rear axle reminiscent of the Chrysler K-cars. It's an effective setup, though it transmits a lot of road noise through the floor pan.

Continued

POPULAR SCIENCE TEST RESULTS

	Plymouth Laser RS	Mitsubishi Eclipse GS DOHC Turbo	Isuzu Impulse Turbo	Ford Mustang GT
ACCELERATION and HANDLING				
0–30 mph (sec.)	2.4	3.1	2.7	4.3
0–60 mph (sec.)	6.7	9.3	7.1	11.8
30–50 mph (sec.)	11.9	11.5	11.2	6.0
50–70 mph (sec.)	12.5	10.5	8.0	7.6
Double-lane change (mph)	56.8	58.0	58.6	56.6
Slalom (mph)	46.4	46.2	48.1	45.9
Road holding (G)	0.83	0.83	0.84	0.84
BRAKES				
60–0 mph cold (ft.)	175	166	174	165
60–0 mph warm (ft.)	161	148	151	153
60–0 mph hot (ft.)	166	148	156	159
INTERIOR NOISE				
Idle (dB)	55	50	45	45
60 mph (dB)	71	71	65	64

SPECIFICATIONS

Engine	5.0-L FI V8	2.0-L FI Turbo I4	2.0-L FI Turbo I4	2.0-L FI I4
Valve train	2 valves/cylinder	SOHC, 2 valves/cylinder	DOHC, 4 valves/cylinder	DOHC, 4 valves/cylinder
Power at engine speed @ rpm	225 @ 4,200	140 @ 5,400	190 @ 6,000	135 @ 6,000
Torque at engine speed (lb.-ft.) @ rpm	300 @ 3,200	166 @ 3,000	203 @ 3,000	125 @ 5,000
Compression ratio	9.0:1	7.9:1	7.8:1	9.0:1
Transmission	5-speed manual	5-speed manual	5-speed manual	4-speed automatic
Final drive ratio	3.730:1	3.910:1	4.153:1	4.322:1
CHASSIS				
Front suspension	Independent, MacPherson strut, coil spring, stabilizer bar	Independent, control arm, coil spring, stabilizer bar	Independent, MacPherson strut, coil springs, stabilizer bar	Independent, MacPherson strut, coil springs, stabilizer bar
Rear suspension	Live axle, four-trailing link, coil spring, stabilizer bar	Live axle, five-trailing link, coil spring, stabilizer bar	Rigid axle integral with two trailing arms, panhard arm, coil spring, stabilizer bar	Rigid axle integral with two trailing arms, panhard arm, coil springs, stabilizer bar
Steering gear	Rack and pinion, power 41.2-ft. turning circle	Rack and pinion, power 31.5-ft. turning circle	Rack and pinion, power 34-ft. turning circle	Rack and pinion, power 34-ft. turning circle
Brakes	Disc, drum power	Disc, disc power	Disc, disc power	Disc, disc power
EPA MILEAGE				
City	17	21	24	24
Highway	24	27	36	34
DIMENSIONS				
Wheelbase (in.)	100.5	96.1	97.2	97.2
Length (in.)	179.6	172.6	170.5	170.5
Width (in.)	69.1	65.7	66.5	66.5
Height (in.)	52.1	51.4	49.8	49.8
Curb weight (lbs.)/distribution (% front: rear)	3,220/58:42	2,951/58:42	2,809/64:36	2,784/64:36
Fuel tank (gal.)	15.4	15.1	15.9	15.9
Interior volume (cu. ft.)/distribution (% front:rear)	95.5/60:40	77.1/63:37	91.0/64:36	91.0/64:36
Trunk volume (cu. ft.)	12.2	12.6	10.2	10.2

PRICES, PARTS, and SERVICE

Base price	$13,272	$16,329	$14,169	$11,417
Price as tested	$14,423	$16,379	$16,799	$13,955
Major options (over $100)	Special value group: power locks, AM-FM cassette stereo, remote mirrors, A/C, power windows $1,794; rear window defroster $145		A/C $788; power package $355; alloy wheels $306; power steering $235	2.0-liter engine $860; A/C $775; 4-speed automatic transmission $775; cassette AM-FM stereo $235
PS SERVICEABILITY				
Total of 12 (maximum of 60 points) items	49	41	39	43
Best feature	Routine maintenance	Spark-plug access	Fluid level	Overall access
Worst feature	Rear spark-plug access	Turbo hoses	Overall access	Oil-filter access
SPARE-PARTS COST				
Brake pads, front	$ 53	$ 39	$ 72	$140
Brake pads, rear	47	39	45	50
Front shock/strut insert (each)	90	57	135	165
Front fender	97	192	165	120
Alternator	233	465	461	530
Fuel pump	224	231	274	400
Ignition module	69	926	n.a.*	n.a.
Grille	329	36	32	n.a.
Front bumper		436	208	180[1]
Windshield	327	234	333	n.a.
Taillight lens	75	64	68	n.a.

* Not available [1]reinforcement

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The Mustang uses a modified MacPherson-strut arrangement up front; the rear end relies on a well-developed four-shock setup on a live rear axle that works better than it looks. The remaining bit of development for the Mustang would be to stiffen the body-chassis structure.

The Isuzu Impulse GT is in some ways a reincarnated car, having had its suspension pieces altered greatly to enhance its handling. The Impulse started life as an Opel Kadett, but the real change in character came when Lotus Engineering Ltd. attempted to cure handling problems that could best be described as erratic.

Lotus took the unusual route of softening the suspension, then greatly enhancing shock damping. The engineers attempted to eliminate unwanted front-end toe changes as the body rolled by relocating key suspension pivot points. The car feels soft and supple, while providing the driver with a solid feel.

But the Eclipse's overall agile feel and the ability to turn the car quickly allowed it to dominate the double-lane-change test. Second was the extremely fluid Isuzu Impulse, while the Mustang was slowed through the cones both by chronic understeer and its wider girth. The relatively slow throttle response of the Laser seemed to be a handicap, but it managed to finish only 2/10 mph slower than the Mustang.

The order of finish for the cars snaking through the slalom course was similar, with the Eclipse Turbo easily dominating and the less muscular Laser trailing the field; the Mustang took second, and the Impulse third.

Our last test found the Mustang to be the only car in the group without rear disc brakes, which gave it the longest stopping distance of the coupe quartet despite having the most favorable weight distribution. Regardless, it still managed a respectable 161 feet with good control after the brake pads had a chance to warm up.

But it was in driving these cars in many traffic conditions that each one's character began to crystallize. The Lotus modifications improve the Impulse so it offers a unique package—a small sporty car with rear drive that is somewhat limited by a lively, but mediocre by comparison, engine. After some fumbling, I got used to the unfamiliar grouping of windshield-wiper switch, heating controls, and turn signal placed on movable pods to each side of the steering wheel, which at first seemed a big irritation.

As the sleepy sister of the group, the Laser demonstrated the merits of the basic Diamond-Star coupe package. It's a more compact, more upbeat car that is also slightly more agile than the Mustang. The Japanese-American coupe's exterior styling is striking and the interior is well laid out and contemporary, limited mainly by a cramped rear seat. The Laser's performance, when equipped with the automatic, actually felt worse than the test numbers indicate, because it was most annoying in stop-and-go driving when the high-revving engine didn't get a chance to come into its own.

The turbocharged power plant and five-speed change the character of the car altogether. It's powerful, and in the same league with the Mustang once it gets rolling and the front wheels get some grip. Its crisp-shifting gearbox and pedal location make this car a joy to drive. But it's also a tricky car to drive. The copious power available makes for some disconcerting steering action.

In many ways it makes a strong statement for four-wheel drive, because the turbo appears to be pushing the limits of front-drive traction. In fact, Chrysler and Mitsubishi will offer four-wheel-drive versions of the Diamond-Star car in the near future. Having driven prototypes of the four-wheel-drive turbo car in Japan, I can attest that four-wheel drive offers a cure for many of the torque problems we encountered.

All in all, the Mustang still offers some of the most driving fun for the money in a sporty coupe. The near-classic appeal of the straightforward V8 and rear drive, combined with some effective suspension design work make it a particularly nice package.

I'd still opt for the turbo version of the Eclipse/Laser, however. I prefer the modern styling, agile handling, and raw power despite the quirks. Without the rough edges, the four-wheel-drive version should be even better. PS

BRUTE FORCE VS. FINESSE

This is the granddaddy of all confrontations: the brute force of a sledgehammer versus three high-tech ball peens.

The Mustang is of the old school: powered by a big V8 and decidedly rear drive. The Diamond-Star twins—a turbocharged Mitsubishi Eclipse and a non-turbo Plymouth Laser—are the latest sports coupes on the block. They are flashy, sophisticated, and eager for a fight. The Isuzu Impulse falls somewhere in between: It's a middle-aged design with turbocharged four-cylinder power and rear drive.

Without further ado, I'll blurt out my strong preference right now: the Mustang GT. Even though it's in its 11th model year, this car has been polished to a fare-thee-well, and it's more fun to drive than any car costing less than $15,000 has any right to be. The engine is a tower of usable power; the transmission shifts quicker than you can snap your fingers; the seats lock you down; and the steering keeps you in touch with the road. The one shortcoming is the brake system: The Mustang's disc-drum design doesn't deliver stopping performance in keeping with its otherwise razor-sharp reflexes.

The turbo Eclipse is breathtakingly quick, but you can't use all of its remarkable horsepower and all of its tenacious grip at the same time. Step down on the throttle in a hard corner, and your path widens appreciably. Nail the gas while the wheels are straight, and the steering feels disconnected. In other words, the mix of 190 hp and front drive looks fine on the test-results page, but it feels squirmy when you press it into service on the road. The Mitsubishi's kid sister with the less potent engine and automatic transmission appears to have taken a wrong turn on the assembly line. It's wonderful for what it is, but it should not be playing hardball with the hairy-chested sports coupes in the neighborhood. The Isuzu Impulse tries hard, but just doesn't quite get the job done. The Lotus-developed chassis feels stable, but not very agile. The turbocharged and intercooled engine needs more displacement and a more-modern combustion chamber—or in other words, more power. The Giugiaro-styled bodywork appears aging alongside the Diamond-Star duo and is ready for an update. I want to see if this company catches up with the field when the Impulse's replacement is announced in six months or so.—*Don Sherman*

COUPE COMPARISON

	Chevrolet Beretta GTU	Dodge Daytona Shelby Z	Ford Probe GT	Mazda MX-6 Turbo	Nissan 240 SX	Toyota Celica GT-S
Engine specs						
type/size	V6/2.8 liter	Turbo 4/2.2 liter	Turbo 4/2.2 liter	Turbo 4/2.2 liter	In-line 4/2.4 liter	In-line 4/2 liter
horsepower @ rpm	130 @ 4,700	174 @ 5,200	145 @ 4,300	145 @ 4,300	140 @ 5,600	135 @ 6,000
torque @ rpm	160 @ 3,600	200 @ 2,400	190 @ 3,500	190 @ 3,500	152 @ 4,400	125 @ 4,800
Acceleration						
0–30 mph (sec.)	2.8	3.0	2.5	2.6	2.9	3.2
0–60 mph (sec.)	10.0	8.4	8.2	8.1	10.2	10.8
Braking						
60–0 mph (ft.)	146	146	142	154	143	174
Price as tested	$14,493	$16,574	$16,276	$18,099	n.a.*	$17,943

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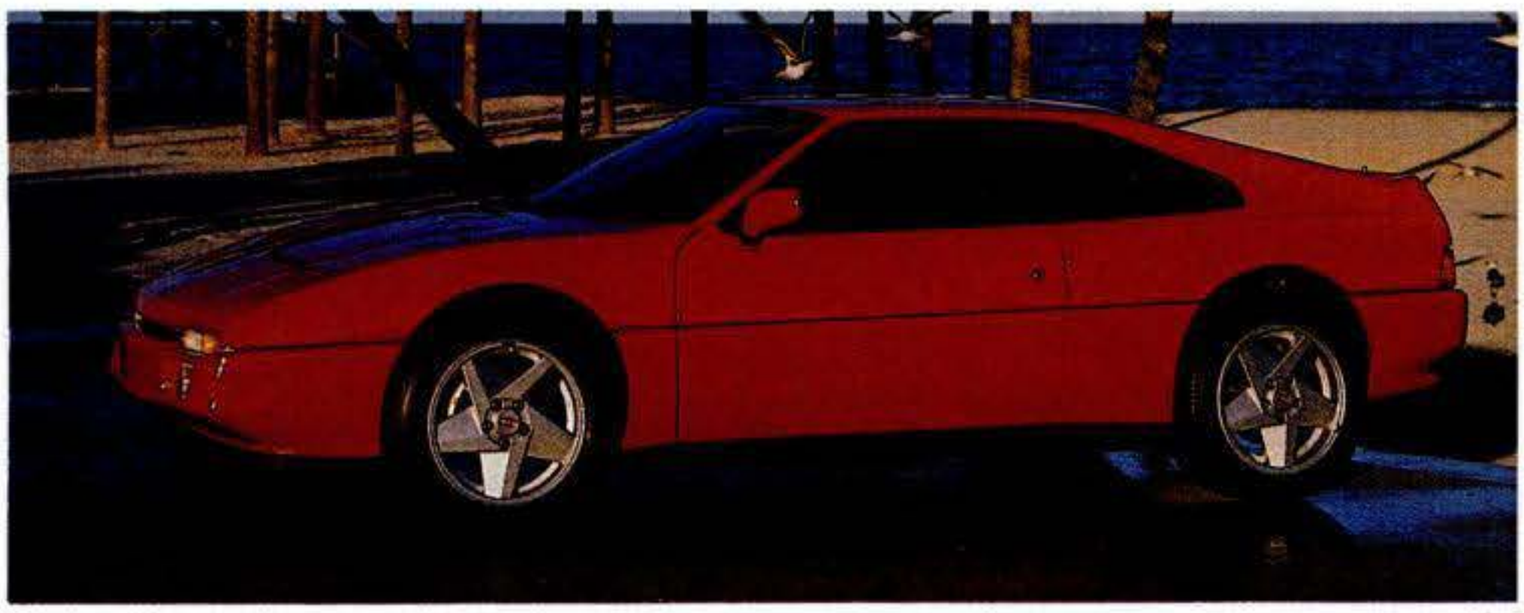
BY DAWN STOVER

What's New

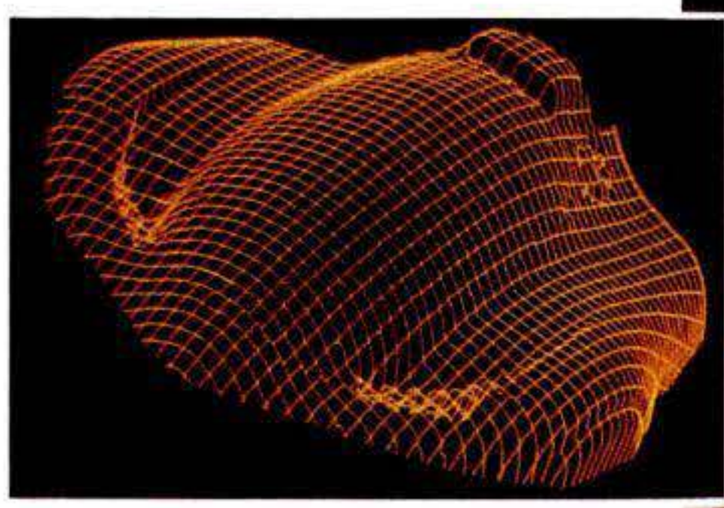


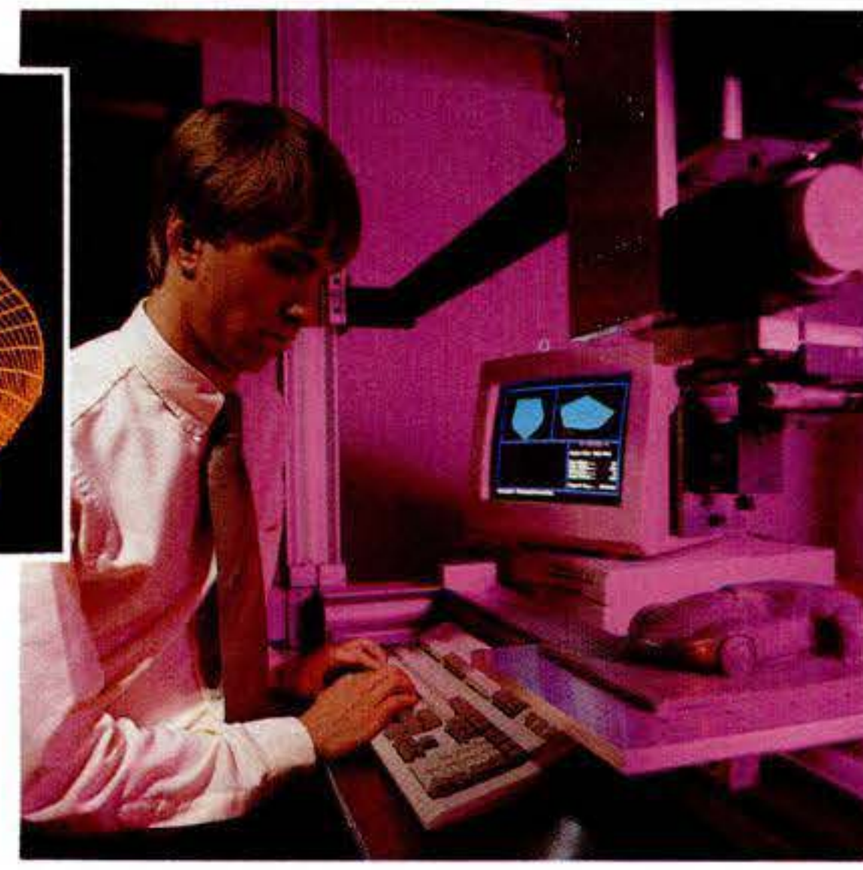
Mid-engine with 200 horsepower ▲

There are only three of these French sports cars in America, but more are coming. Powered by a 2.5-liter turbocharged overhead-cam V6, the $70,000 MVS Venturi is "elegant, not visually shocking." It combines familiar styling elements (like the Corvette front end and the BMW M1 side profile) with a luxurious interior.

Self-draining shoe ▲

The Hydro-Tech boat shoe won't hold water. Designed to help sailors keep their footing and stay warm, it allows water to flow out through vents on the side and back of the sole. Timberland makes the $90 shoe, which is available in men's sizes 6 to 14.



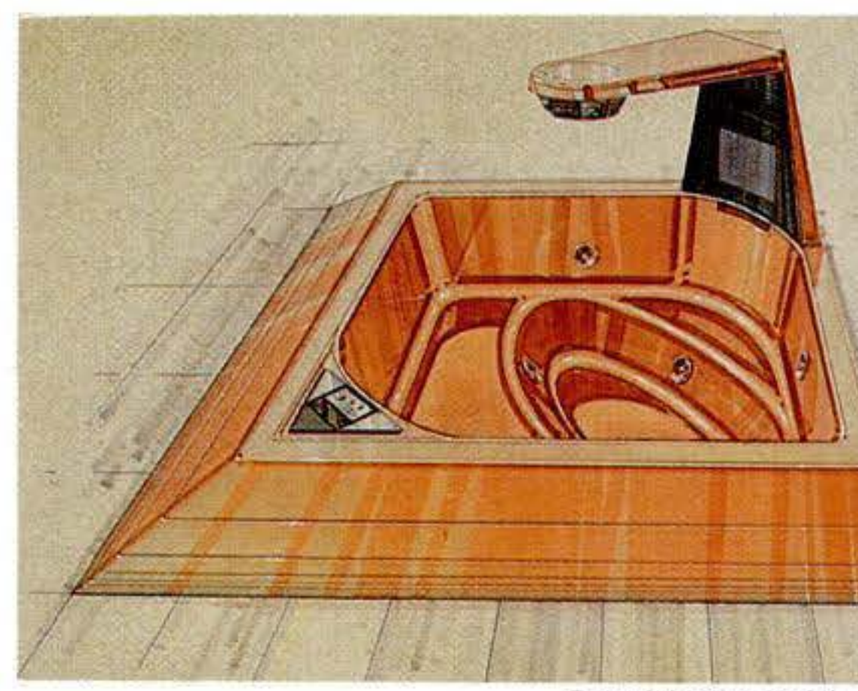


3-D laser digitizer ▶

Pity the engineer assigned to modify a part designed years ago with pencils and paper. He'll have to measure all the critical dimensions of the part physically and enter them into the CAD (computer-assisted design) system—just as much work as designing the part from scratch. The alternative: a laser digitizing system that bathes a part (in this case, a clay model of an auto body) in light, gauging the positions of thousands of points on the object's surface. These points can be translated, on a CAD terminal, into a wire-frame model (inset) that the designer is free to manipulate. Laser Design, 8316 Pillsbury Ave. S., Minneapolis, Minn. 55420.

Motorized runabout ▲

The fold-up Mosquito has a top speed of 18 mph and a lower center of gravity than a human-powered scooter. A 30-cc two-stroke engine is integrated with the rear wheel, and there are hydraulic brakes on both wheels. Luc Moreau, 48 rue St. Sabin, 75011 Paris, France.



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World's largest drilling platform ▲

This 1.4-million-ton concrete oil platform required enough steel reinforcement to build 10 Eiffel Towers. When it's towed to the Gullfaks field off the Norwegian coast and placed on a base more than 860 feet tall, Gullfaks C will be the biggest man-made object ever moved, says its builder.

◀ On-board solar power

A photovoltaic array, paired with a retractable canvas sun roof atop the Tech Deck, charges the batteries for a microwave oven and refrigerator. The 25-foot pontoon boat also gets some power from a 100-hp Evinrude outboard. Lowe, Box 989, Lebanon, Mo. 65536.

◀ Bathing in style

In the year 2000 you may be a prune instead of a couch potato. According to designers at Jacuzzi Whirlpool Bath, your bath will have a high-definition 3-D TV, a hands-free videophone, a beverage dispenser, built-in ultraviolet tanning lights, and a voice-controlled shower. If you long for the good old days, turn on the massaging water jets.

Engine upgrade ▶

The 1989 Range Rover sports a 3.9-liter V8 engine that produces 19 percent more horsepower than its 3.5-liter predecessor, says Range Rover of North America. The British-built vehicle can now hit 60 mph in just under 11 seconds. The new Rover also has an automatic all-time four-wheel-drive system.

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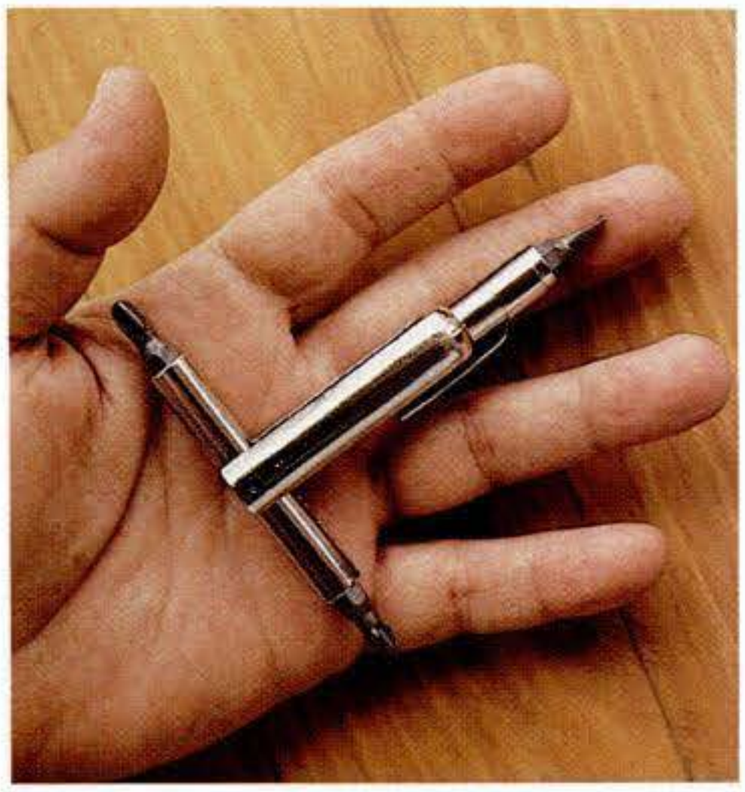
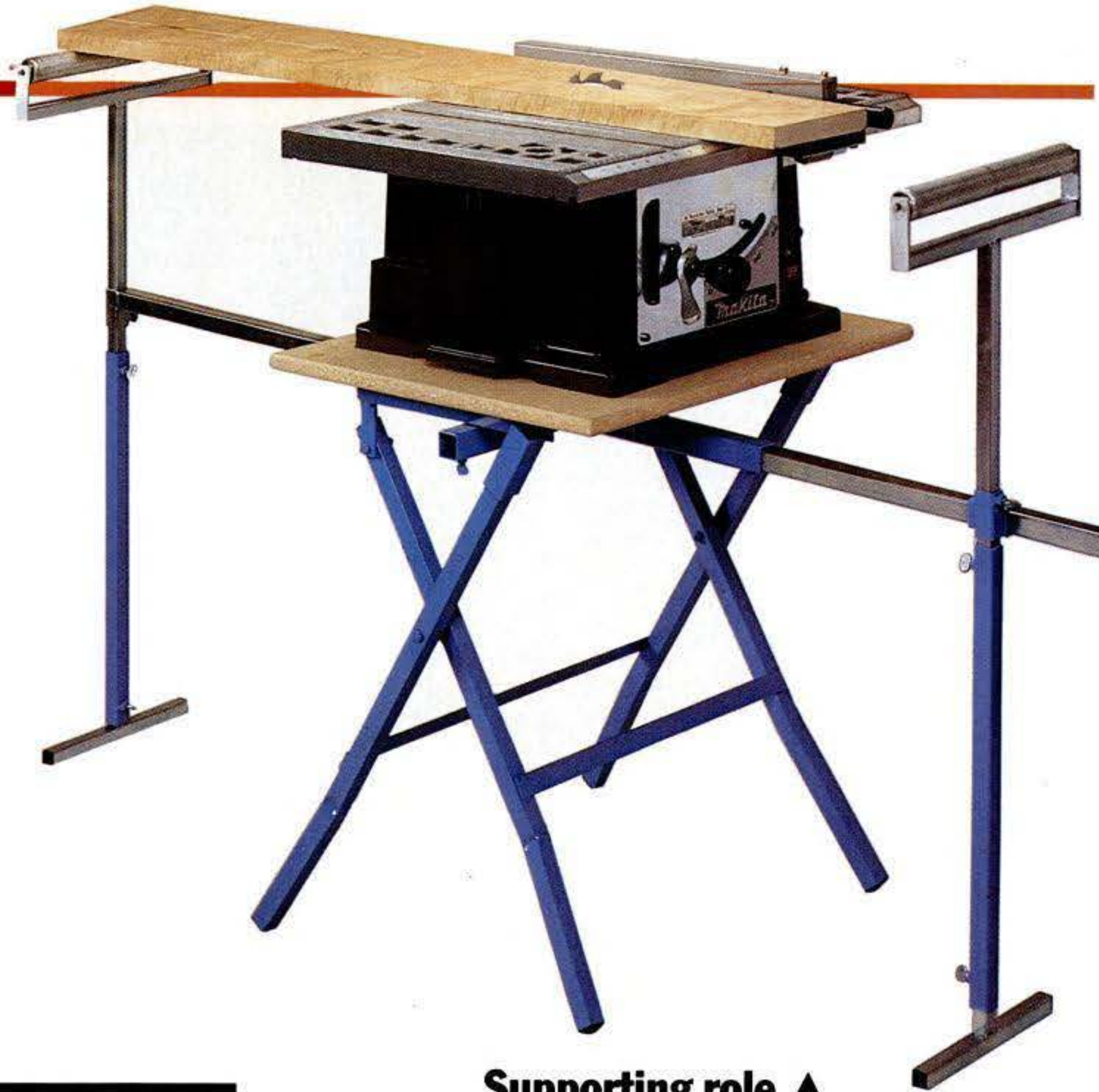
BY V. ELAINE GILMORE

What's New TOOLS



Seven in hand ▲

Six screwdriver tips—three slotted and three Phillips on double-ended bits—are always available with this stow-anywhere driver, which also can handle ¼-inch nuts. Its T-handle pivots to align with the stem. Metro Mailing, 619 Montgomery St., Brooklyn, N.Y. 11225; $10.

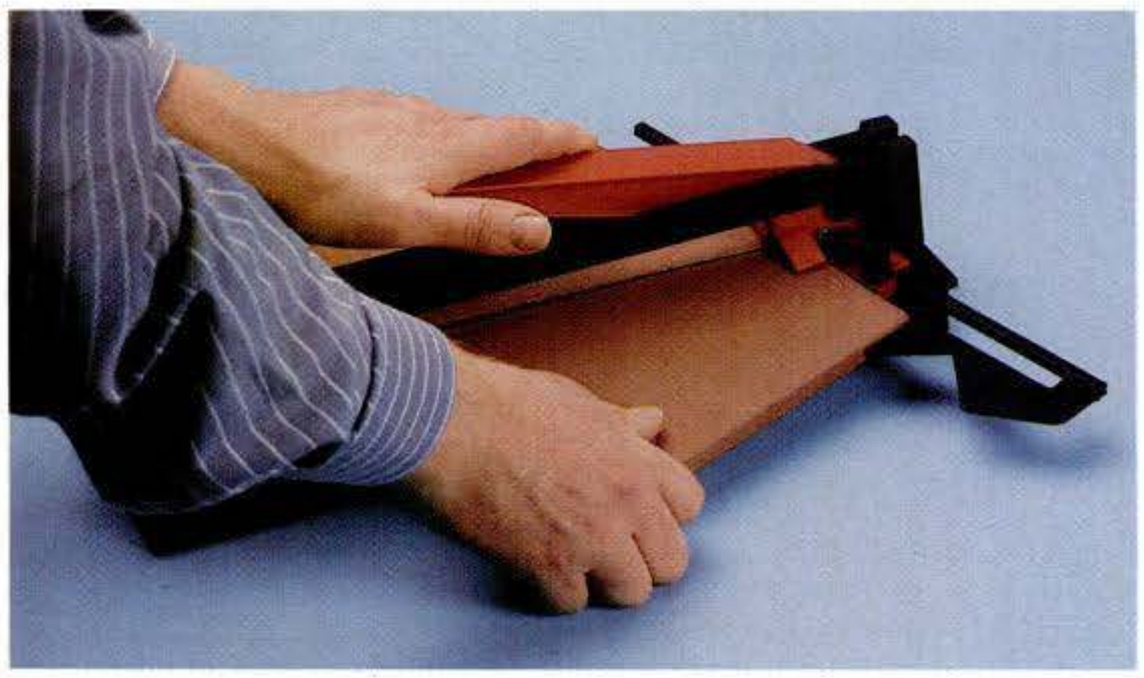


Supporting role ▲

This foldable stand, called Pow'r/Mitermate, has a 20-by-24-inch fiberboard top to hold any eight-inch bench-top table saw, miter saw, or mini planer. Outriggers, with ball-bearing rollers, extend 42 inches and can be placed at table sides or fore and aft. Woodcraft Supply Corp., Box 4000, Woburn, Mass. 01888; around $150.

How to pick 'em ▶

Leichtung's pick-up magnet not only grabs ferrous metal parts, it also dumps them. When you pull up on the plunger the magnet moves away from the bottom plate, demagnetizing it, so you don't have to pick the parts off one by one. It's $15 (plus tax) from Leichtung Work Shops (4944 Commerce Pkwy., Cleveland, Ohio 44128).



Clever cutter ▲

Two things make the Vitrex 2800 quarry floor and wall tile cutter versatile: The height of its lever adjusts, so you have maximum leverage for snapping regardless of tile thickness. And it can lock the tile in cutting position at angles up to 45 degrees. Made in England, it is imported by Dejond, Inc. (7 Emery Ave., Randolph, N.J. 07869); $50.

◀ That's all?

It's a try square, miter gauge, angle finder, marking gauge, depth gauge, level, compass, ruler (10-inch steel), and straightedge. It's called the David Multi-Marker and it's made in Holland (where it won first prize at an inventor's contest). Themans Tools, 5721 G Bayside Rd., Virginia Beach, Va. 23455. Price: around $16.

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BY STUART F. BROWN

What's New RECREATION

Get noticed, live longer ▶

Motorcyclists, bicyclists, and anyone else out at night need to be seen to be safe. The Urban Survivor in America Visibility Vest catches car headlights with bands of highly effective Scotchlite retroflective material, says Conspicuity Inc. (5435 N. Lawler Ave., Chicago, Ill. 60630). Price: $60.

◀A place for bikes

Where to put the bikes? The oiled oak wood PedaStyle storage rack holds two cycles in felt-lined cradles. Holders for two more bikes are optional. A "no holes" mounting design leaves ceilings and floors undamaged. PedaStyle costs $189 from IMS Enterprises (Box 16577, Wichita, Kan. 67216-0577).

Paddle rower ▲

Here's a boat you row, but without oars. The Aquamobil's pivoted handlebars rotate two paddles independently through cables, so turns are made with one-sided pulls. The builder is Acomo Produktion AG, Seefeldstrasse 10, 3600 Thun, Switzerland.

We're right here ▲

The GPS NAV 1000 uses the global positioning satellite system to plot a boat's location and course. At $3,000, it's the cheapest GPS device yet, says Magellan Systems (1900 W. Garvey Ave. S., West Covina, Calif. 91790).

◀Feedback for fitness

The $200 Nike Monitor's synthesized voice announces time, speed, and distance of a runner's or cyclist's workout. Its Doppler effect sensor detects motion from ultrasound signals bounced off the ground, says Nike, Inc. (11000 S.W. 11th St., Beaverton, Ore. 97005).

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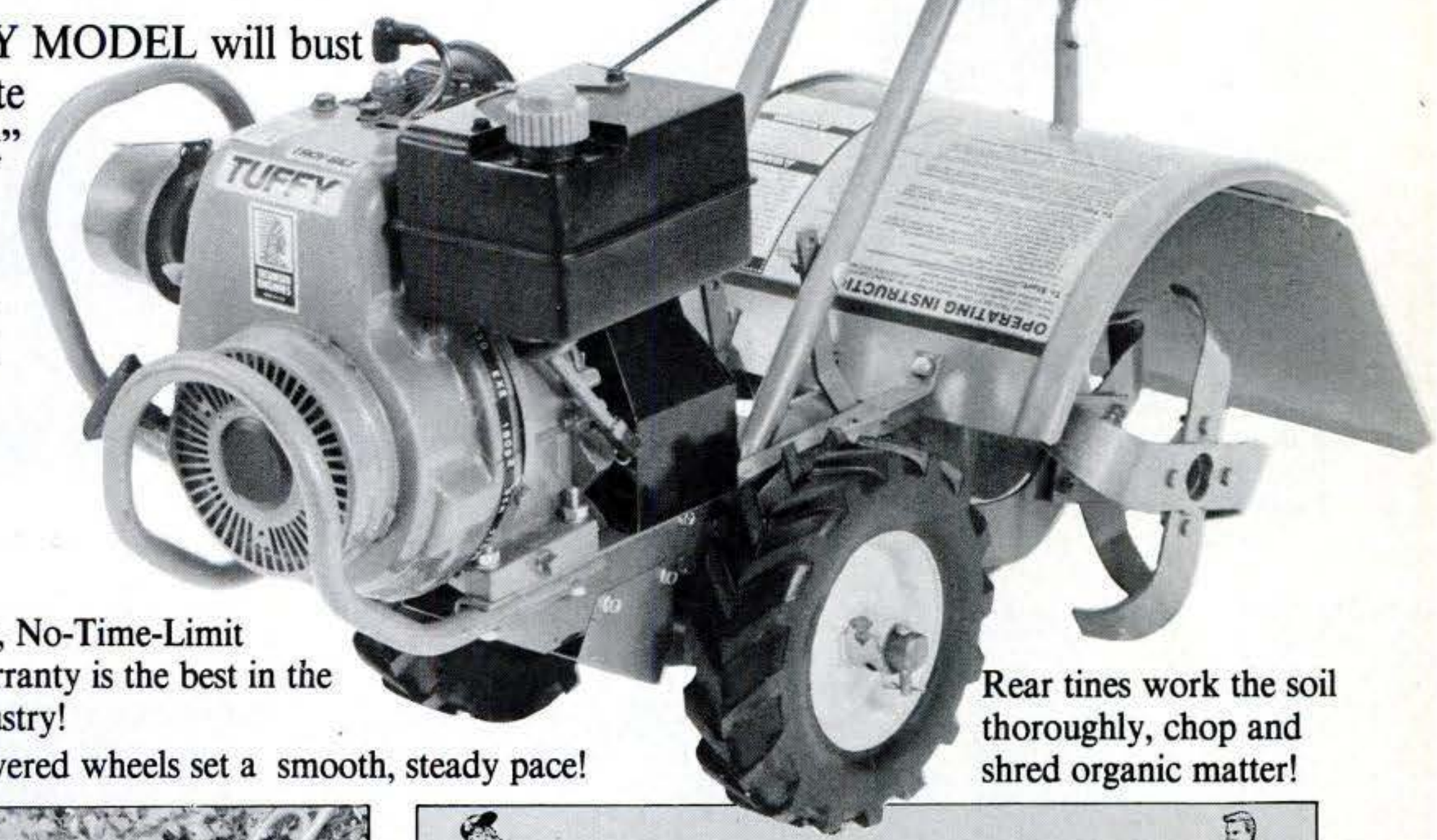

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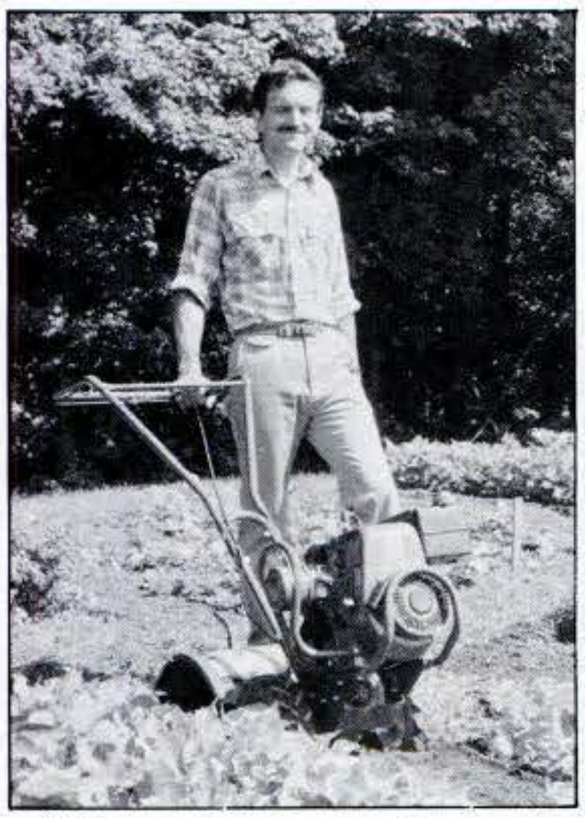

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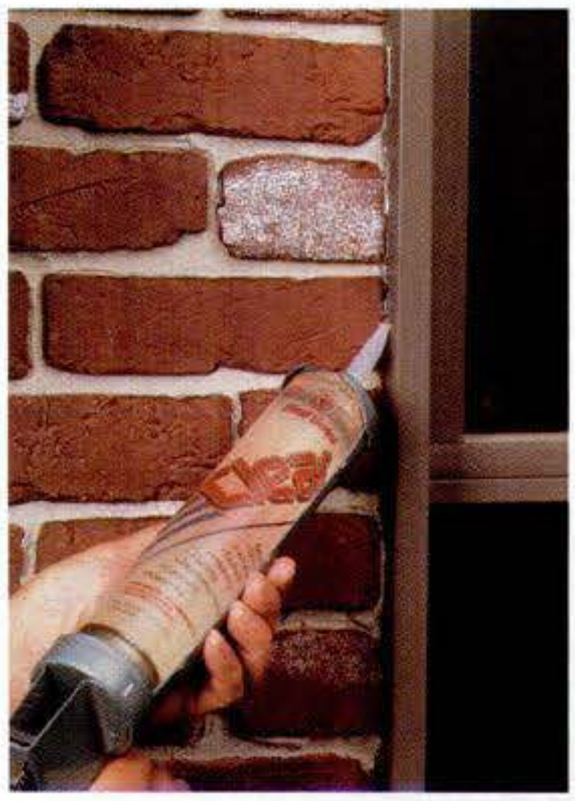
BY TIMOTHY O. BAKKE

What's New HOME

Sturdy corners ▲

The triangular shape and extra fastening points on the 992 Heavy-Duty Corner Brace give it five times the strength of other braces, says Stanley Hardware (195 Lake St., New Britain, Conn. 06050). Available in two-, three-, and four-inch sizes, the brace costs from 95¢ to $4.85.



Crystal clarity ▲

This clear solvent-based polymeric caulk remains clearer than other clear caulks, including silicones, claims the maker. The interior-exterior caulk is paintable, should that need arise. Price: $5.40 (5½-ounce tube), $7.60 (10.3-ounce cartridge). Red Devil, Box 194, Union, N.J. 07083.

Hot glass ▲

Heated glass eliminates condensation and cold downdrafts from windows. These triple-glazed windows have the inner pane coated with a transparent film of electrically conducting stannic oxide. Fed with normal AC voltage at only 70 watts per square meter of glass area, the glass temperature is kept at about 63 degrees F when it's minus four outside, says the maker, Termofrost AB (Box 8, 163 93 Spanga, Sweden).

Shower bi-folds ▲

What's missing from these shower doors? Slider tracks. Fashion Fold doors fold into the tub (or shower stall) or the bathroom, and the curve at bottom keeps water *inside*. Waterline Products Co., 117 Vulcan St., Rexdale, Ont. M9W 1L4; $468 to $768.

◀ Clean-air vacuum

The Silverstar's Air Clean cassette, an electrostatically charged air-filtering and freshening system (inset), removes 99.9 percent of the dust and pollen in the exhaust air, says Miele Appliances (22F World's Fair Dr., Somerset, N.J. 08873). A tool caddy is built into the canister; about $750.

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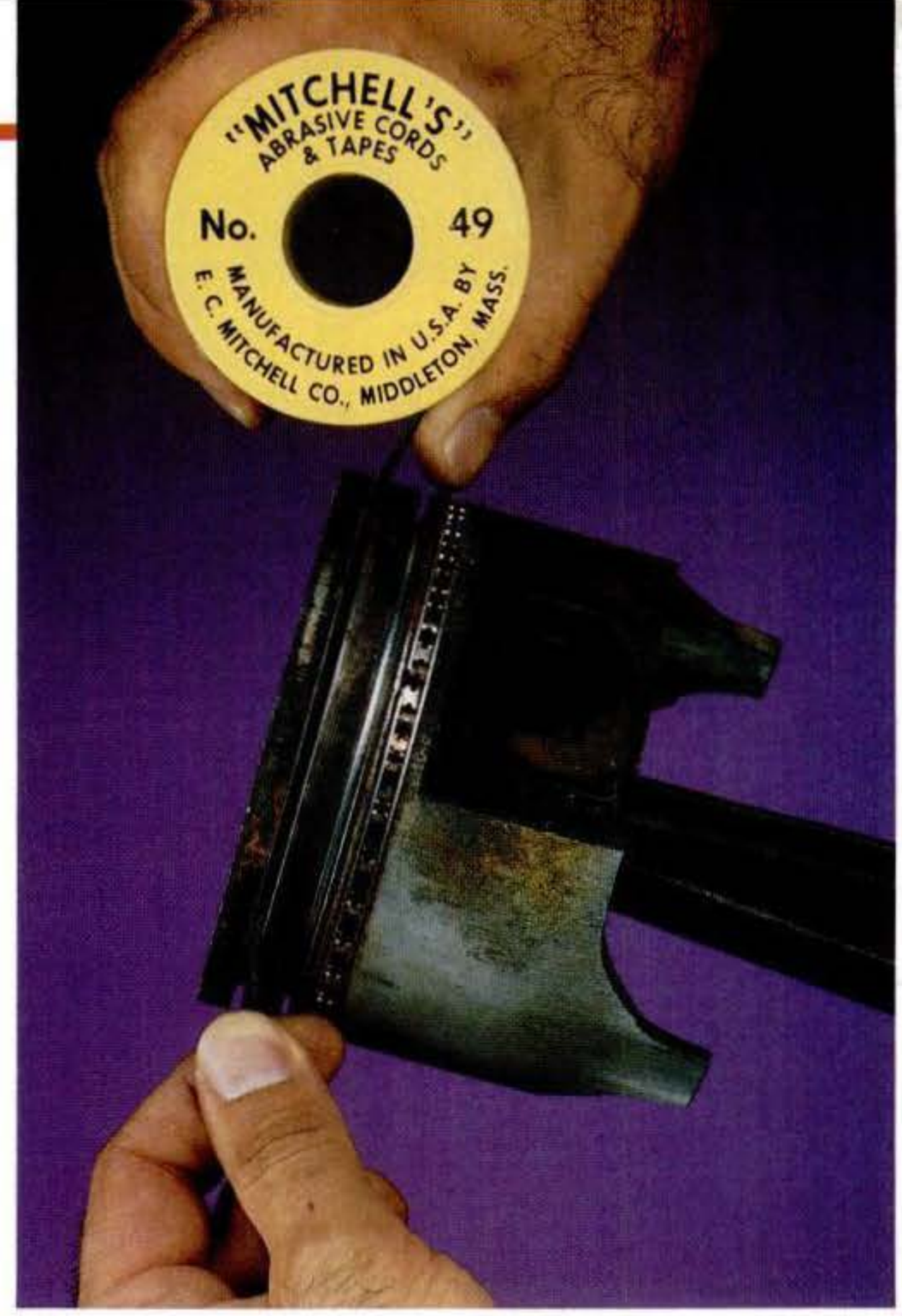
BY BRIAN NADEL

What's New CARS

Pressure checker ▶

A quick look at Tire Savers should show whether your tires are properly inflated. The balloon is in view (bottom) when pressure is at or above 22 psi, but retracts (top) below 22 psi. Devices for other pressures are under development. International Rerid Corp., 2210 Cratten St., Riverside, Calif. 92504.



Cleaner cord ▲

Baked-on carbon can be removed from tight spots with abrasive cords and tapes, says E. C. Mitchell Co. (88-90 Boston St., Middleton, Mass. 01949). Abrasive materials include aluminum oxide, crocus, and silicon carbide, in widths ranging from 0.012 to 0.150 inch. Prices vary from $11 to $50 per spool.

Spill-proof fill-up ▲

This fuel filler neck snaps shut after the gasoline nozzle is removed to prevent gasoline from spilling and vapors from escaping. Molded of heavy-duty plastic, it is now available only for BMW or Mercedes-Benz cars. Temtec GmbH, Box 1164, 8201 Raubling, West Germany.

◀ Digital pressure

Tire pressure can be accurately measured with this lightweight digital pressure gauge, according to Neotech Industries (8150 Springwood Dr., Irving, Texas 75063). The $30 gauge attaches to the tire's valve to read from 2 to 99.5 psi, within one-percent accuracy, according to Neotech.

Roadside hose repair ▼

If a radiator or heater hose springs a leak, the Ideal/Parker repair kit should get you back on the road. The company suggests cutting the hose on both sides of the leak, inserting the fluted plastic pipe, and tightening the hose clamps. Kit price range: $5 to $10.

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ISO-TEMP TOOLS. AS TOUGH AS THE PEOPLE WHO USE THEM.

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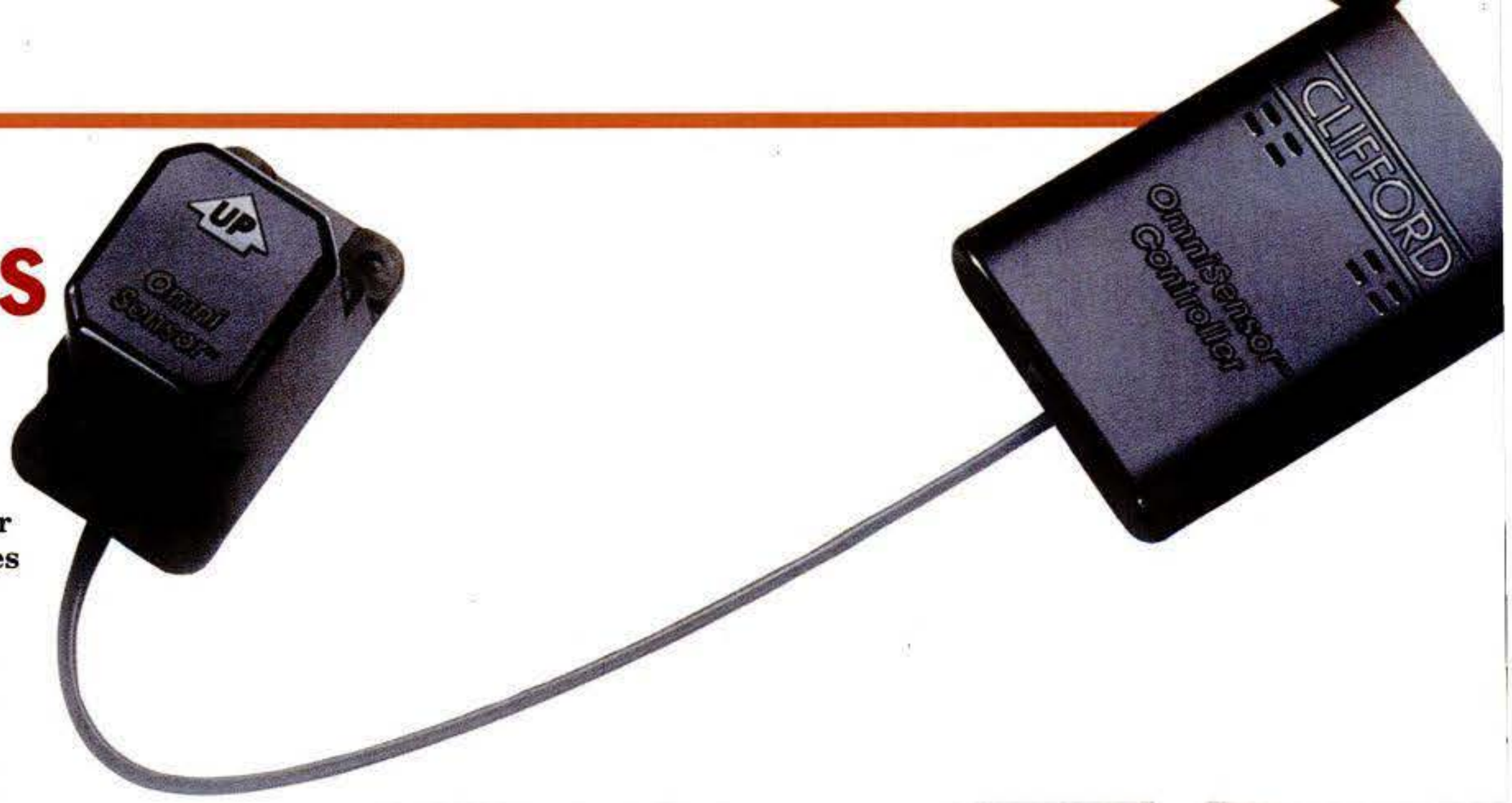
BY WILLIAM J. HAWKINS

What's New ELECTRONICS



Intelligent sensor ▶

Attached to your car's burglar alarm system, a microprocessor in the OmniSensor determines if its sensors are registering road noises or a thief is trying to break in. The smart snitch then sounds the alarm. It's $69 from Clifford Electronics (20750 Lassen, Chatsworth, Calif. 91311).

Super Super-VHS ▲

Take an S-VHS VCR that's capable of recording with 400-line resolution, then add strobe motion, nine-screen picture-in-picture, on-screen programming, high-speed and index search, stereo hi-fi, and remote control. Result: Pioneer's VH-930SD. Price: $1,500.

Say-it phone ▲

Lift the handset, say a name—like Mom—and the Voicexpress telephone dials her for you. The phone's speech-recognition system finds one of 50 preprogrammed numbers and is 98-percent accurate, says maker Origin Technology (627 E. Taylor Ave., Sunnyvale, Calif. 94086); $180.

Car video ▶

Load the kids in the back seat and strap them in. They'll be fine once you turn on Hitachi's five-inch made-for-the-car color LCD TV. The 27-ounce prototype is designed for TV broadcasts and videotape, but, claims the maker, it can be used in the future as a navigation and instrumentation display too.

◀ On-the-go video

Portable pleasure: Emerson's 10-inch color TV includes a built-in VHS videocassette player, and operates on AC house current or a 12-volt battery. That lets you watch TV and tapes just about anywhere. The VCT120 is $500.

Remote remote ▶

Hide the hi-fi—in a cabinet or another room—and you prevent its remote control from working. Solution: the Hidden-Link. It receives infrared remote-control signals and sends them via cable to the out-of-sight stereo system. It's $50 from Xantech Electronics (12950 Bradley Ave., Sylmar, Calif. 91342).

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Optical film

"It's a big step forward for both discs and tape," boasted ICI Electronics marketing manager Michael Strelitz. His company is a division of the British chemical giant ICI. Earlier this year it introduced optical storage film that can hold volumes more information using less space—and money—than other currently available optical or magnetic media. Key to the development is a special dye that's "tuned" to an infrared wavelength from a laser.

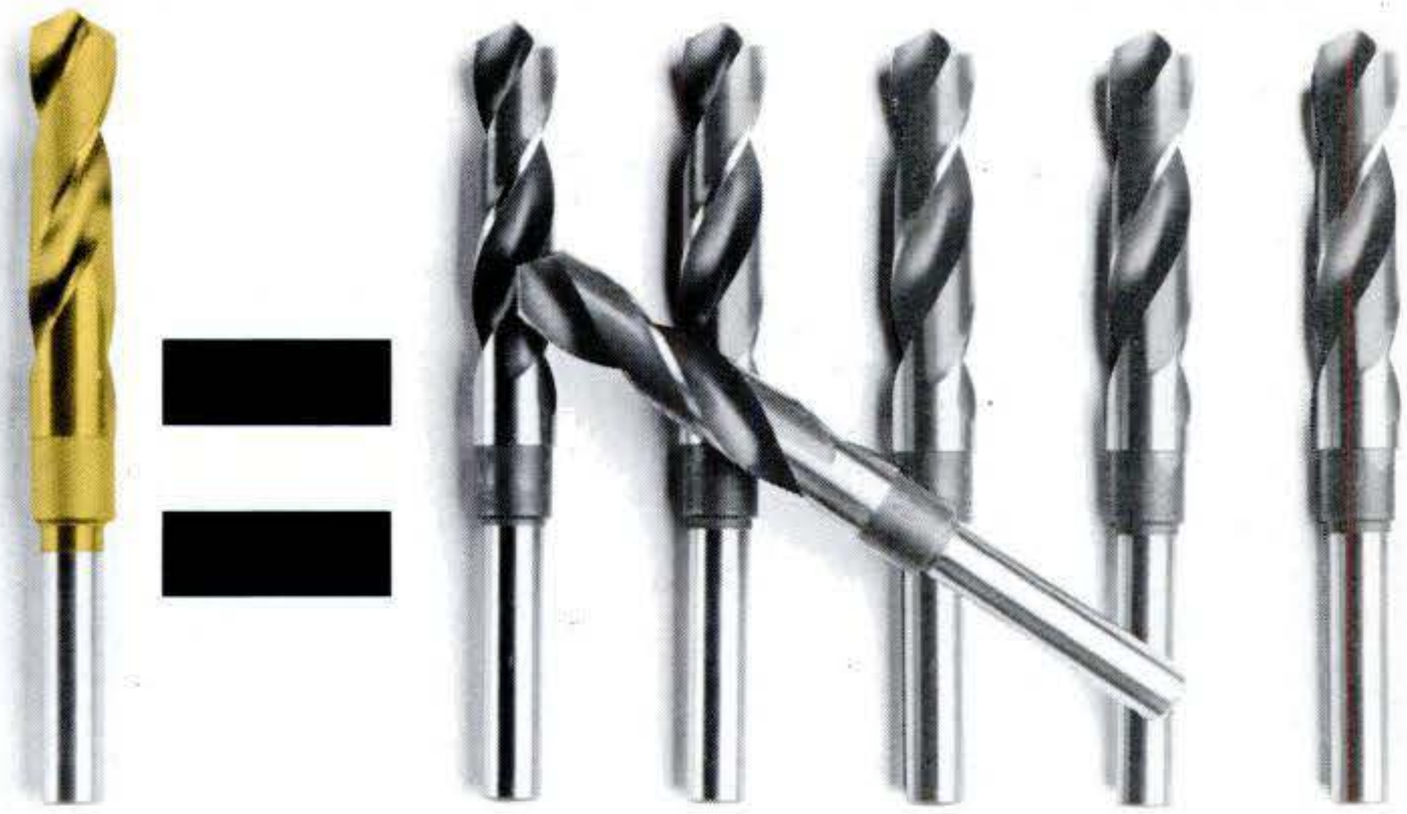
As a floppy, Digital Paper is said to store as much information as 833 1.2-megabyte 5.25-inch magnetic disks. As a tape, it stores the equivalent of 5,000 IBM 3480 magnetic tapes, claims ICI. And, at ½ cent per megabyte, it costs one-tenth as much as other tape.

Digital Paper has an infrared-absorbing polymer dye on a flexible polyester-based substrate (see diagram). A semiconductor laser shines an infrared beam on the film's color-tuned coating, producing a pattern of pits, or spots—an optical data recording of digital bits.

The one-micron-wide (0.00004-inch) spots make the amazing storage density possible because the concentric tracks can be close together. Microscopic dimensions also mean less power is needed to "write" the spots.

That cuts costs, but Digital Paper's main saving is from high-volume production. With one continuous process, the tape is made in 600-millimeter (23.6-inch) widths, "and we turn that out in one-kilometer [0.6-mile] lengths," Strelitz told me. The film can be sliced to the required width for tape or punched out into discs. Because it is coated only on one side, double-sided floppies are formed with two pieces.—*David Scott*

EVERYTHING YOU NEED TO KNOW ABOUT TITANIUM.



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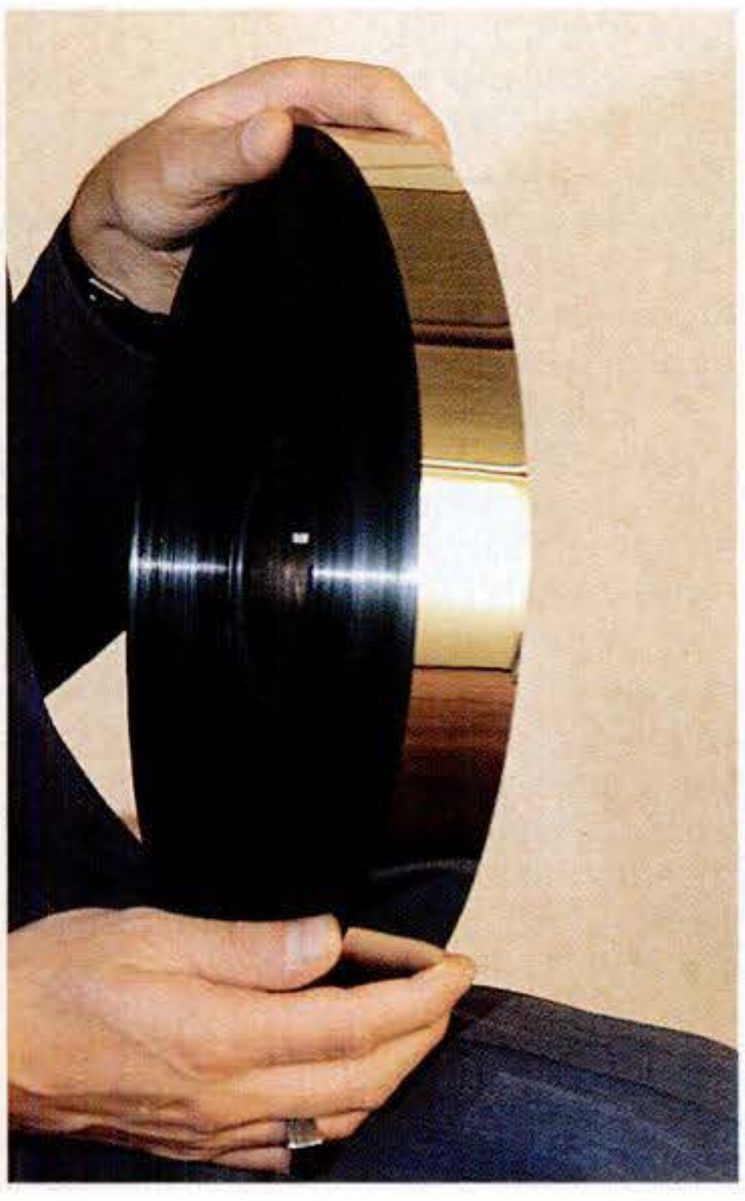
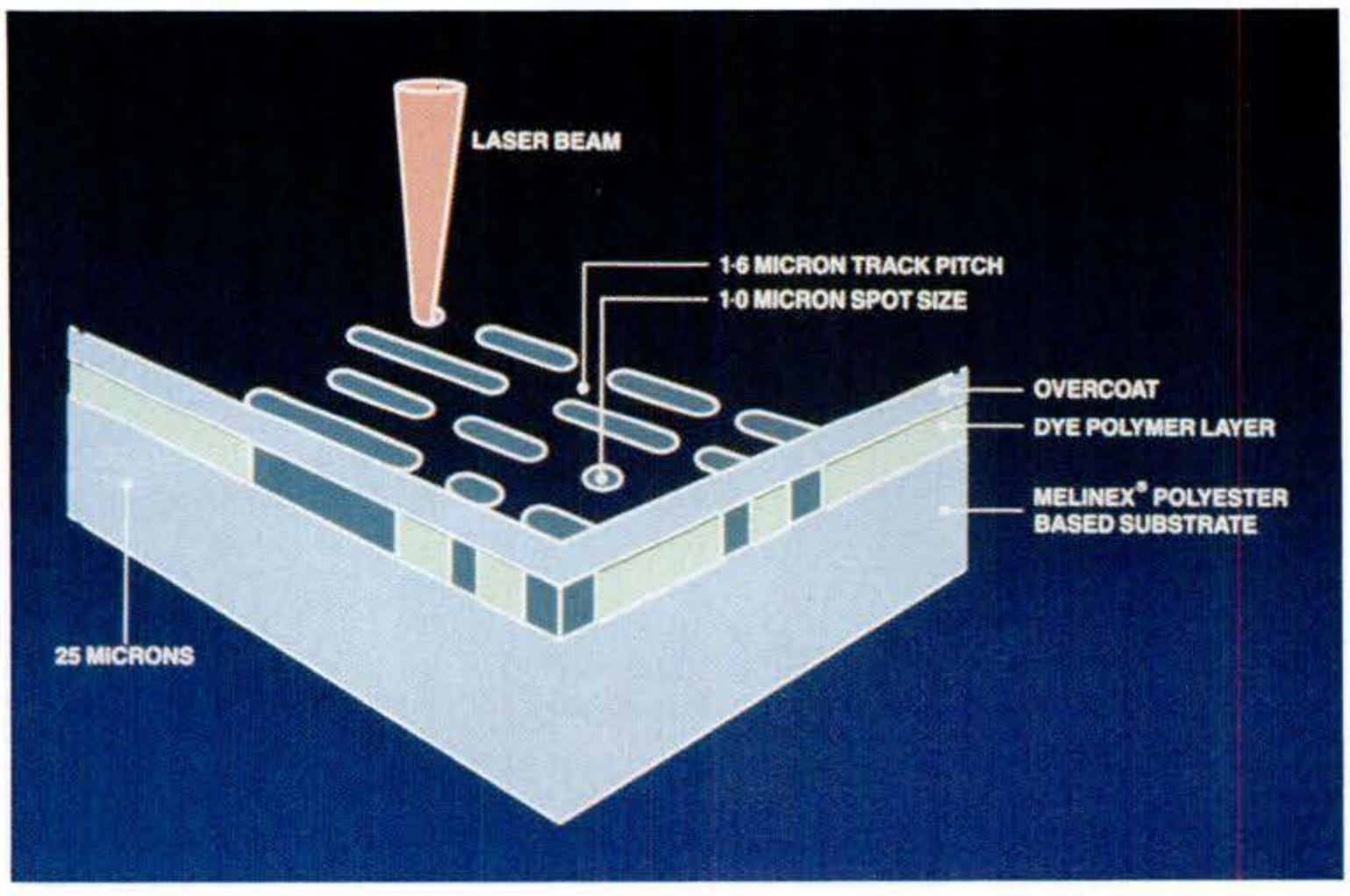


Twelve-inch reel of 35-mm optical tape stores 1,000 gigabytes of data—enough to fill one billion sheets of paper—with an average access time of 28 seconds.



Infrared laser beam reacts with heat-sensitive dye layer on substrate of Digital Paper, forming microscopic pits that store densely packed data.

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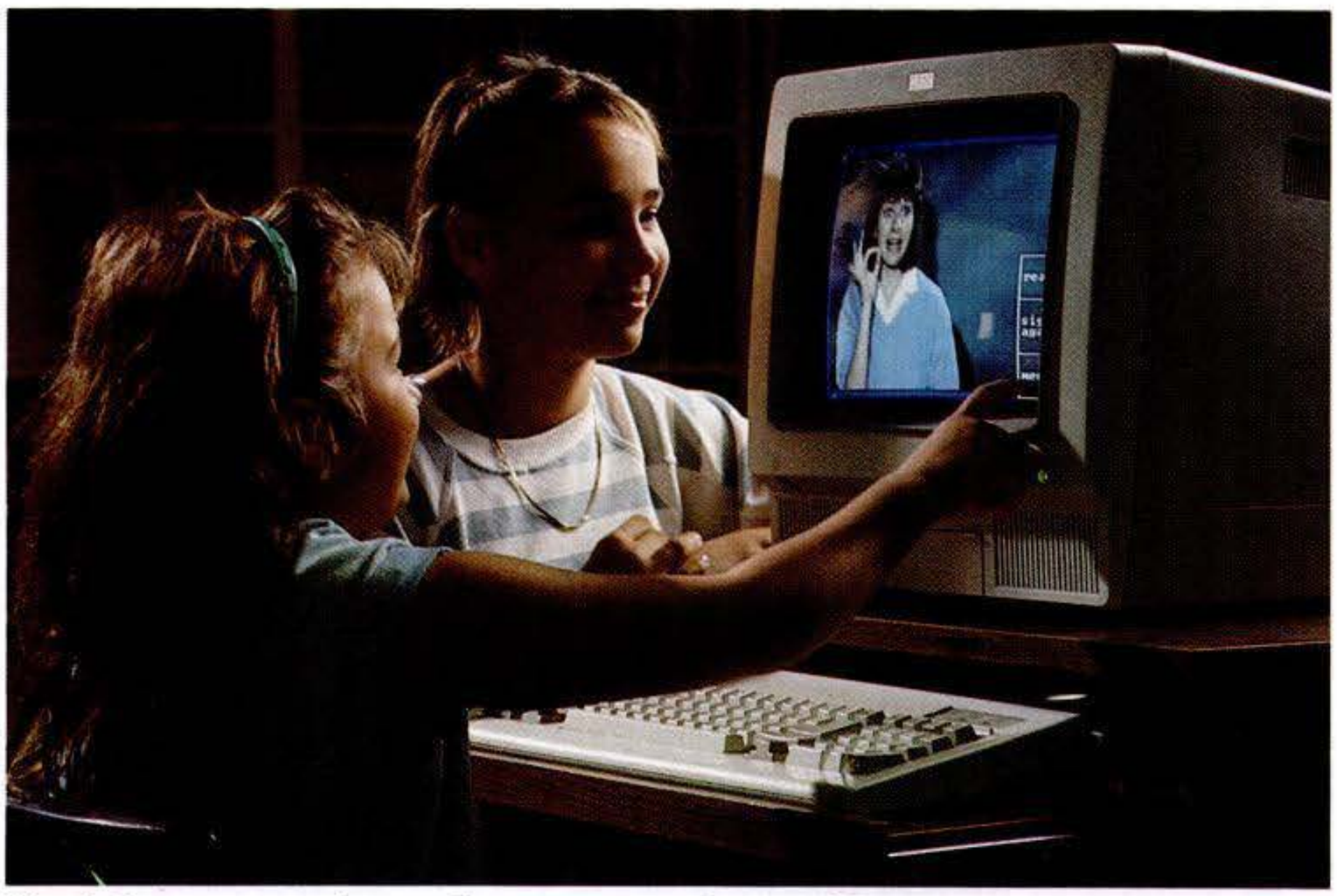
Electronics Newsfront

By WILLIAM J. HAWKINS



HandsOn, an experimental computer program IBM helped to develop, aids deaf children in improving their ability to read and write.

A computer that helps

"English is like a foreign language for many deaf students," says IBM researcher Vicki L. Hanson. So two years ago Hanson and Carol Padden, associate professor of communications at the University of California at San Diego, began HandsOn, an experimental program that enables children fluent in American Sign Language to learn written grammar and vocabulary. Says Hanson: "The aim of the project is to use a personal computer combined with new videodisc technology to aid in developing the English skills of these children."

Designed for third- through sixth-grade students, the HandsOn program combines text and laser-disc pictures on a touch-sensitive IBM InfoWindow display monitor. The newest videodisc focuses on science stories that range from information about house cats to dinosaurs.

By touching graphic boxes on the screen a student can read the text of a story and watch as it is signed. By touching other boxes the child can change the speed at which the story is given or even return to a particular part of the story to see it again. The student answers questions—given as text, sign, or both—by typing on the computer's keyboard.

The computer also pulls out particular scenes in the story for the student to caption using the written text for help with vocabulary, spelling, and grammar. When the scenes are played back, the text creates the effect of a subtitled television show.

While tests are still underway, researchers feel confident that the HandsOn system will ultimately help the 8,000 deaf high-school students who graduate each year with only a fourth-grade reading level.

PACS—Picture Archiving and Communications Systems—can integrate medical images and text-based information.

DEC picks PAC

Digital Equipment Corp. calls them PACS—Picture Archiving and Communications Systems (see photo bottom left). They let image-based information, such as X-rays, be combined with textual data about a patient and be electronically stored, displayed, or sent via a network to other computers. For example, using Digital's DECrad program with PACS, a radiologist can look at diagnostic images in one screen window while reading a patient's medical report in another.

For your PC

- What's a space ornithologist? According to Sky Publishing (Box 9111, Belmont, Mass. 02178-9111) it's the study of space birds—or satellites. The company's $41.50 Space Bird program helps you spot them in the sky. Besides an IBM PC, all you'll need is binoculars.
- With a program from PC Software Services (16405 Bridge End Rd., Miami Lakes, Fla. 33014), your computer's dot-matrix printer doesn't print—it *writes* letters and notes and addresses envelopes to look as if they were done by hand. Longhand is $99.
- Select a college based on tuition costs, academic field, or its rating using the data supplied in College Probe. It's $25 from Carolina Programs, 1904 Overland Dr., Chapel Hill, N.C. 27514.
- Send fonts to your laser printer at speeds of up to 50,000 bits per second *in the background*—while you continue using the computer for other work. It's done by Backloader, a utility program from Roxxolid (pronounced "rock solid"), 3345 Vincent Rd., Pleasant Hill, Calif. 94523. Price: $30.
- SoftKlone has updated Mirror II with Mirror III (logical), a data-communications program that now in-

Continued

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cludes a dialing directory and 100 additional commands. It's $100. Address: 327 Office Plaza Dr., Tallahassee, Fla. 32301.

Ready, set, stop

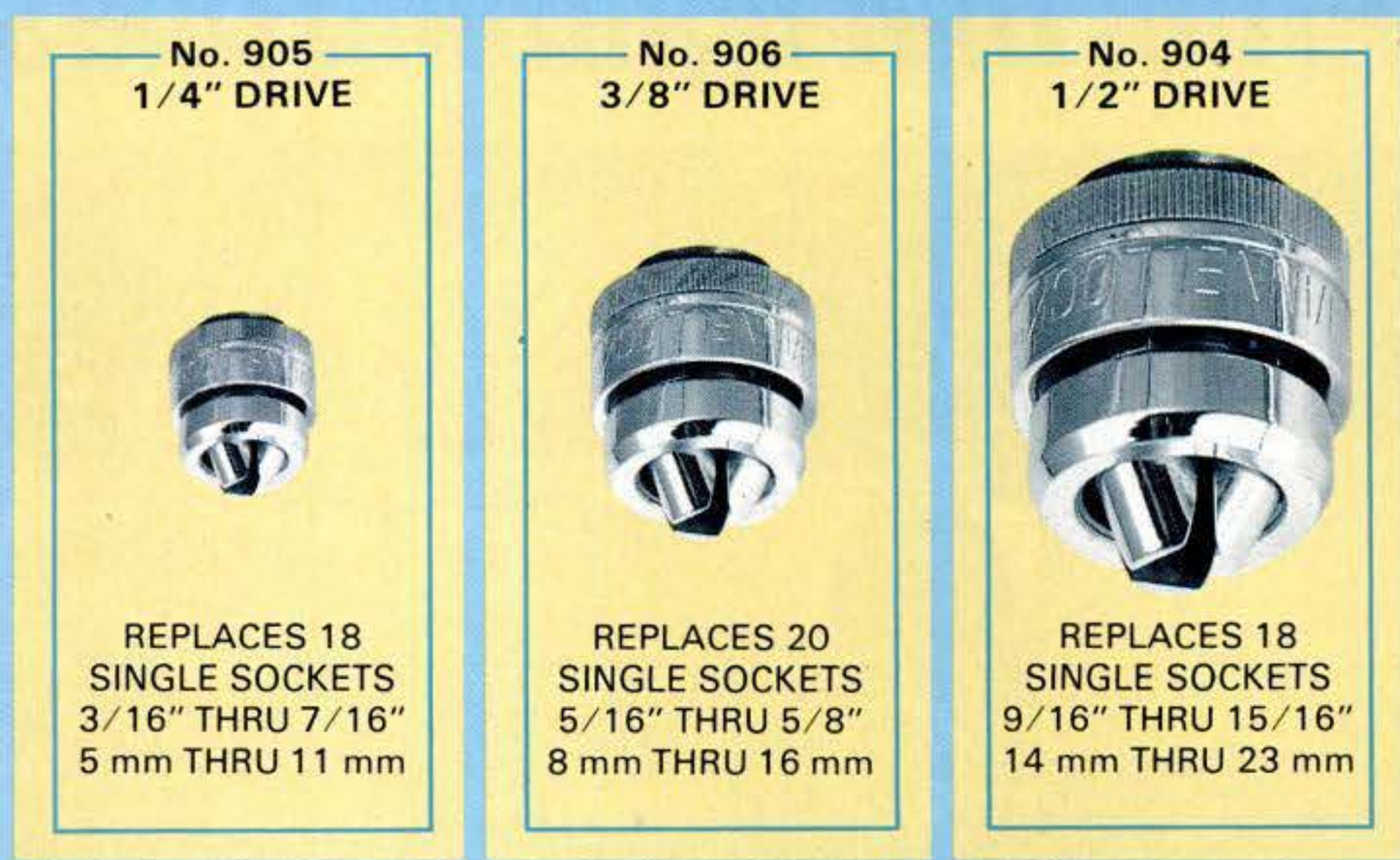
It was a heated race—so heated some contestants had to be immersed in cooling liquid. And despite the location—Argonne, Ill.—the odds-on favorite was from Japan. But before you could say "they're off," it was over. The winner, taking 0.004 second to solve a set of linear equations that required 700,000 arithmetic operations: the Cray Y-MP/832. Eight other Crays came in behind, followed by an ETA 10-E from Control Data Corp. The NEC SX-2, believed to be the world's fastest supercomputer, came in 12th. The slowest machine? Apple's Macintosh took just under three minutes—but it was also the smallest and didn't cost a few million dollars. The race was conducted by Argonne National Laboratory.

Consumer Electronics 1989

Stephen Rondel holds the palm-size box in one hand while he maneuvers a tiny microphone in front of his mouth with the other. "Take me . . . to the . . . airport," he says, pausing just briefly on certain words. He turns the box toward me so I can see the words he has spoken scurry onto its LCD display. "Translate," says Rondel. The box immediately begins to use its synthesized voice to speak in fluent Spanish. The $2,000 electronic translator from Advanced Products & Technologies in Redmond, Wash., was just one of the newest devices shown at the most recent Consumer Electronics Show in Las Vegas. A few others:

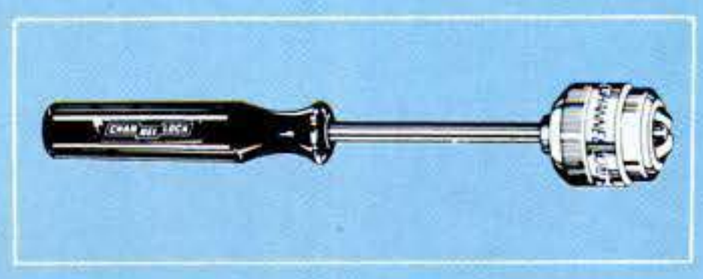
- Panasonic has a hand-held personal LCD TV with a built-in VHS-C video-cassette recorder. Record off-air shows to view later or attach a tiny color camera to the set for home-movie making.
- Canon's ZapShot is a still-video camera that holds 50 pictures on a two-inch disk. The price is approximately $800.
- A home VCR from Toshiba is serious about sound: The hi-fi deck includes a four-band equalizer for the audio.
- Franklin's newest spelling checker uses voice synthesis so you hear the word's correct pronunciation.
- The Writing Phone from Sanyo lets you send messages written on an electronic pad to other writing phones.
- You *wear* Tele-Art's 17-function universal remote control for your audio-video system: It's built into a watch. Tele-Art, 1416 38th St., Brooklyn, N.Y. 11218.
- Sharp's LCD projection-TV system produces a 100-inch picture.
- A cute little bear made by Rabbit Systems (Santa Monica, Calif.) gets mean when thrown into the front seat of your car: If a thief tries to enter, changing the car's internal air pressure, the bear growls a 110-decibel alert.
- A gray-colored VHS-C video cassette from JVC uses thinner tape so the company's two newest C-size camcorders record up to 30 minutes in SP mode, 90 minutes in SLP. JVC's Masani Hoshino, deputy general manager, magnetic products division, believes that the camcorders' low weight (2.6 pounds) and longer recording time will mean the end to full-size camcorders within two years. Will the new tape be squeezed into full-size cassettes for 180 minutes of recording? "We're working on it," says Hoshino. PS

These 3 Adjustables REPLACE 39 Individual Sockets



NO MORE NEED for an army of individual sockets. These three CHANNELLOCK Adjustables replace 39 individual sockets, both standard and metric sizes. Precision made of high grade forged steel, they carry a LIFETIME GUARANTEE.

EASY TO USE
Place adjustable socket over nut or bolt, rotate knurled collar to tightest fit. Triple action jaws are closed into a can't-slip grip.



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No. 905 ND-1/4" and No. 906 ND-3/8" Nut Drivers are provided with spinner handles.

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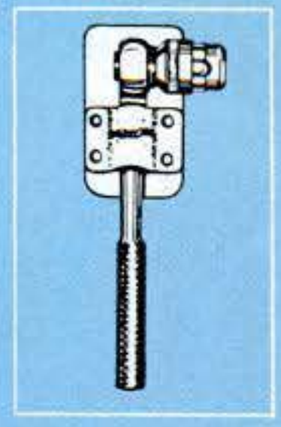

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A new kind of thunder will roar across the desert this year. And with it will come two lightning-fast trucks. It's American Thunder, a new off-road truck team sponsored by Mobil 1, BFGoodrich T/A® and Chevrolet. Three of the most powerful names on the world's racing scene.

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It's only natural then that these three perennial winners would join forces and set out in quest of the SCORE/HDRA championship in Classes 2 and 8. Because competing in this type of competition helps us develop products that perform well on the street. So if you want to ride with a winner, ride with Mobil 1, BFGoodrich T/A and Chevrolet. And feel the power of American Thunder.

Proof that lightning does strike twice.

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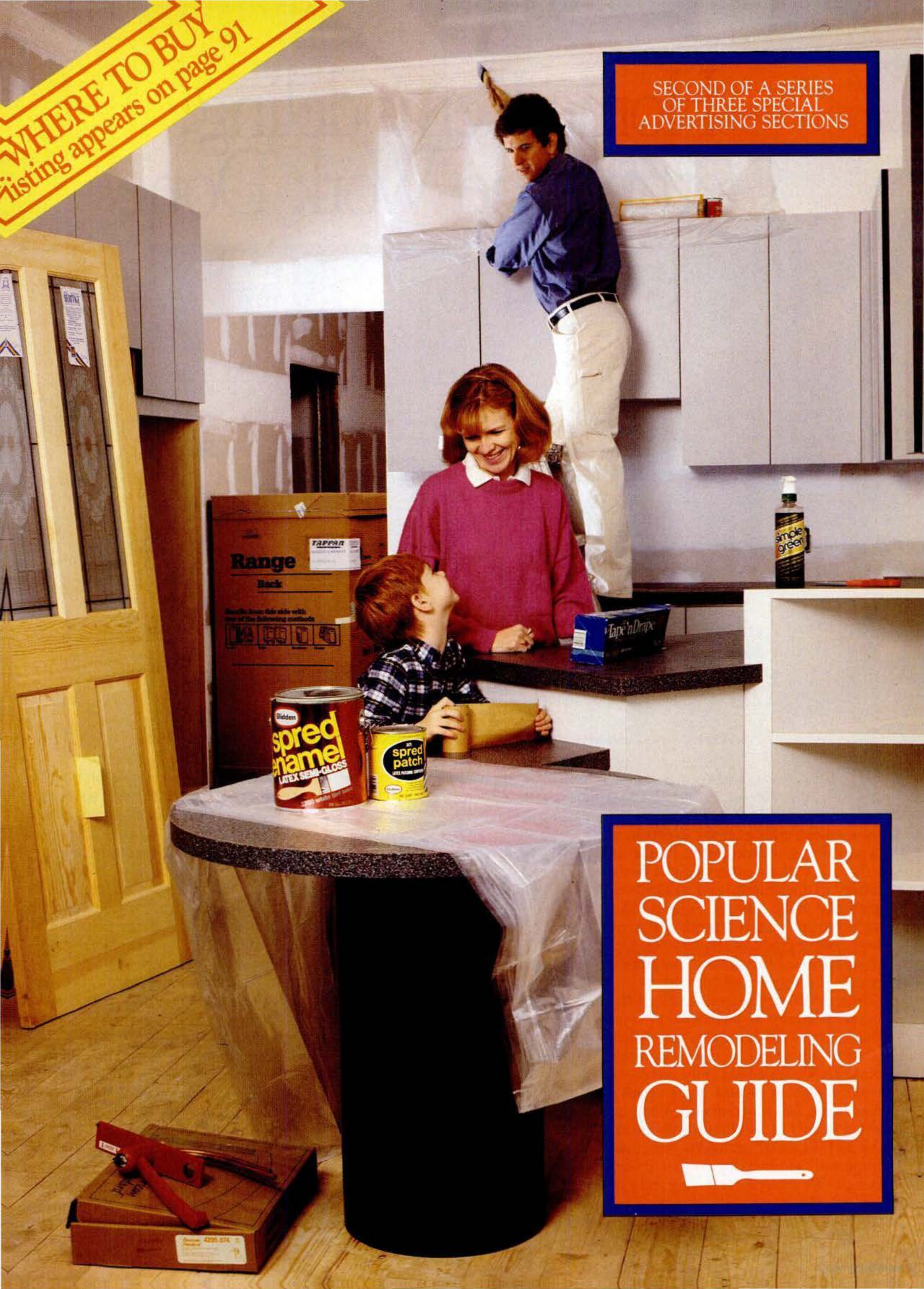
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listing appears on page 91
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POPULAR
SCIENCE
HOME
REMODELING
GUIDE

Home Remodeling: Getting the Work Done

This is the second special section of the *Popular Science* HOME REMODELING GUIDE, a three-issue series drawing on the experiences of remodeling an older home. This series is based on the renovation of a home located in the beautiful town of Madison, about 50 miles east of Atlanta. Our architect and our contractor are using high-quality products and services, supplied by the advertisers who are participating as sponsors and consultants.

In the first section, we described the initial planning and preparation steps that a family would take to completely renovate a home such as the one in this project. We discussed the merits of remodeling your present home versus a new home. We wrote about looking for a new home in a new location and working with Realtors®, architects, structural inspectors, attorneys and other professionals. We wrote about buying and paying for the home. We also included special material about products and services, and promised that the sections to come would continue with this sort of informative material.

About the Front Cover

The new homeowning family is doing some of the work themselves, such as painting the kitchen with durable, scrubbable Glidden Spred® Enamel Latex Semi-Gloss. Daubert Easy Mask® Painting Tape protects new cabinets and counters surfaced with Wilsonart® brand decorative laminates. Simple Green® cleaner stands ready, while a Natchez door by Wing Industries, an energy-saving Tappan gas range and American Standard sink fixture await installation. Models are wearing Georgia Boots™ and clothes by Dickies™.

This is the second in a three-part remodeling case history, with the third section to come in June. You could win the featured remodeled home—or $100,000 in cash.

Or you might win First Prize: a roomy Isuzu Trooper; or Second Prize, an Isuzu Spacecab Pickup. The WIN THIS HOUSE SWEEPSTAKES runs from March 1 to July 31, 1989. Many other prizes, too. For further details, turn to page 91.

Careful planning and preparation has been completed, so it's time to go to work.

Section Two covers most of the hard work of getting the project done—removing, replacing and installing.

In this second section, we select a contractor, make plans with him and work with him. You'll see what happens as he removes the old and replaces it with the new; as he remodels and renovates with energy-saving, high-efficiency, work-saving products and materials. Subjects:

- Home improvements as investments
- Choosing a contractor; doing some work yourself, permits, hauling
- Exterior: Demolition, roofing, gutters & downspouts, painting, tools and fasteners, a photographic record, columns and railings
- Landscaping: mowing, saws, tools and storage, music, irrigation
- Interior: Electrical, plumbing, heating & cooling, insulation, windows, doors, locksets, floors, kitchen, bathrooms, bedrooms, finishing and painting

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Choosing a Contractor

A project, such as the *Popular Science* home, that involves remodeling a whole house may be too big or too complex to do yourself. Such remodeling generally falls into the "just-too-difficult" category. Or you just may not have the time or the inclination to do the tasks yourself. So, at some point, you'll probably consider using a professional remodeling contractor. You may want to serve as the general contractor yourself, while turning over major projects (plumbing, electrical, heating and cooling, structural, insulation, for example) to a specialized subcontractor.

We decided quite early that we would employ a general contractor. We needed someone who could be in close contact with the project and take complete charge of it. We selected Darcy Messina of Atlanta for our project because of his reputation for on-time performance and broad background in both new home construction and remodeling projects.

It is most important to know as much as possible about what you want to do *before* you even approach a contractor. *Don't be nebulous!* Spell out as much as you can as clearly as you can and make sure the contractor understands you.

Make sure that the person you talk to will be taking an active role in your project, and is an established contractor with an office—not just an answering machine.

Find a contractor you're comfortable with, who believes that your plans are feasible. Ask for references and check with his former customers. Is his firm well established, with a good reputation for reliability and on-time performance within budget?

If you decide to use a general contractor, make sure that he has comprehensive insurance. Darcy suggests that, whether you are contracting with the subs yourself or dealing through a general contractor, you should make sure that subcontractors on the job also have insurance coverage.

Always deal with workmen and subcontractors through the general contractor to avoid confusion and to maintain

General Contractor Darcy Messina discusses scheduling in the storeroom of the *Popular Science* remodeling project. Sitting on Olympic® exterior paint, he is surrounded by Owens-Corning Fiberglas® insulation batts, Glidden interior enamel and Marvin Windows' E-Z Tilt Pac.

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his responsibility for the overall project. If you see work being done that is contrary to your wishes or specifications, **tell the workmen to stop working immediately.** Call the contractor, tell him why you have stopped work and straighten out the problem with him directly. The sooner you stop the work, the less expensive the revisions or corrections will be.

Have You Considered Working With a Pro?

Let's assume you know all of the advantages of turning your renovation or renewal project over to a general remodeling contractor, but for reasons of your own you don't want to do that.

Then let's assume you have considered becoming your own general contractor and hiring the specialists or subcontractors yourself. In doing so, you become aware that you don't know enough about these subs to select good professionals, work with them to best advantage and supervise all of the various jobs involved.

There is another viable approach. Consider having a professional contractor

Darcy Messina, general contractor chosen for our project, meets in the great room with his foreman to discuss Kwikset locksets, which will be used throughout the house. The Copa knob design shown here will enhance interior Wing doors. Note the exterior door lockset and deadlock, the detailing on the handsome new mantel, the new gas fireplace and the new pine floors.

Elegant Locksets Greet Guests in Style.

Kwikset® is the No. 1 choice of builders, hardware retailers and homeowners because of the superior quality and premium value that is built into every Kwikset product. All of their products are engineered and manufactured with care and precision to give years of lasting reliability. The kind of reliability you would expect from America's leader in locksets.

Kwikset offers a choice of seven unique and elegant knob designs to enhance the beauty of your home. All are available in a variety of functions for any interior or exterior door, and come in a choice of beautiful polished and antique finishes. (Note the polished brass finish on the Copa knob below.)

For an exciting new look throughout the home, Kwikset's stylists have combined high fashion with the functional efficiency and European charm of leversets. Five distinctive leverset designs are available in a selection of functions and finishes. They are becoming an ever-growing part of the decorating themes in America's homes.

Kwikset entrance handlesets add a touch of elegance to your entry in a variety of functions to meet any need. The Barkley design provides a striking first impression for our *Popular Science* remodeled house. There is an extremely large selection of Kwikset handlesets to choose from. All handlesets are available with a choice of interior knob or lever designs.

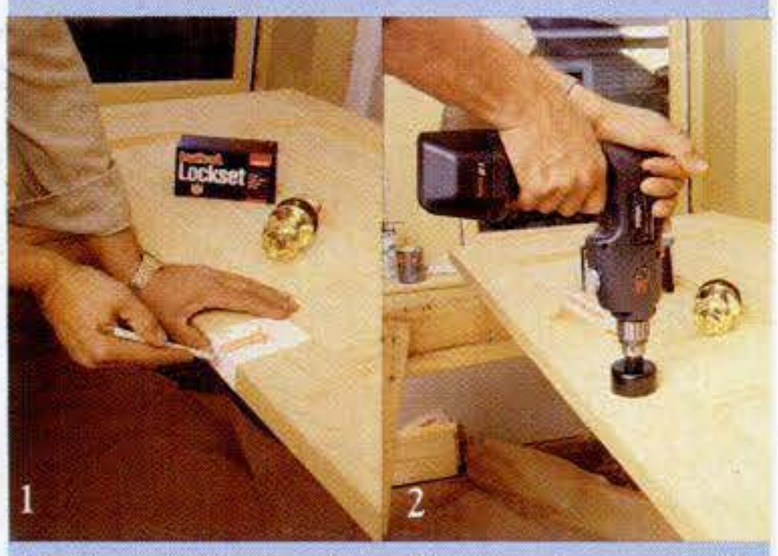
Cylinder deadlocks (also known as deadbolt locks) are considered to be one of the most effective ways of increasing home security and protecting your family and possessions from intruders. Kwikset's heavy-duty 880 Series Deadlocks are used for demonstration by over 13,000 Law Enforcement Agencies throughout the United States in their crime prevention programs. All model deadlocks may be keyed alike for one-key convenience with any Kwikset entrance lock.

Installing Kwikset products is fast and easy. A lockset or deadlock can be replaced in just minutes. Easy to follow instructions and templates are in every package. Kwikset products in their distinctive clear packaging are easy to find. They are sold at virtually every hardware, building supply, home center and locksmith retailer in the country. At the Kwikset display you'll find every kind of doorlock made with quality workmanship and the finest materials. Kwikset has built its reputation by providing beauty and security for entrances with design coordination for all interior doors throughout the home.

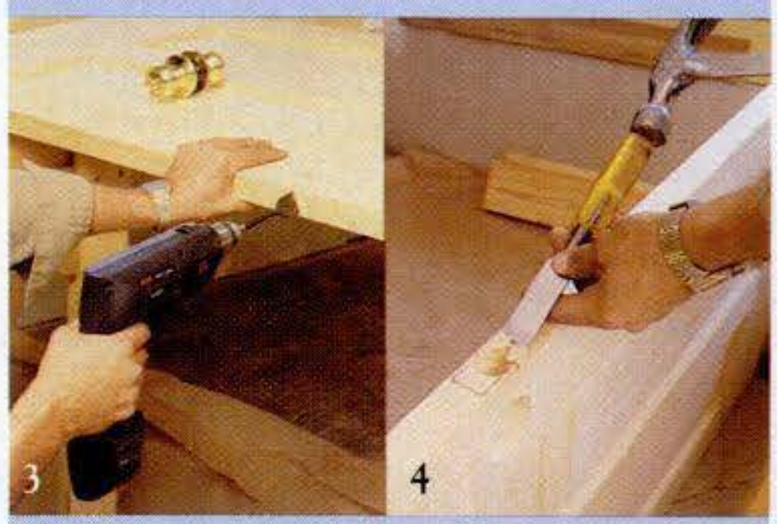
Kwikset Corporation is a pioneer in quality consumer locking and is a member of the Emhart Corporation Consumer Products Sector.

How to Install Kwikset Locksets.

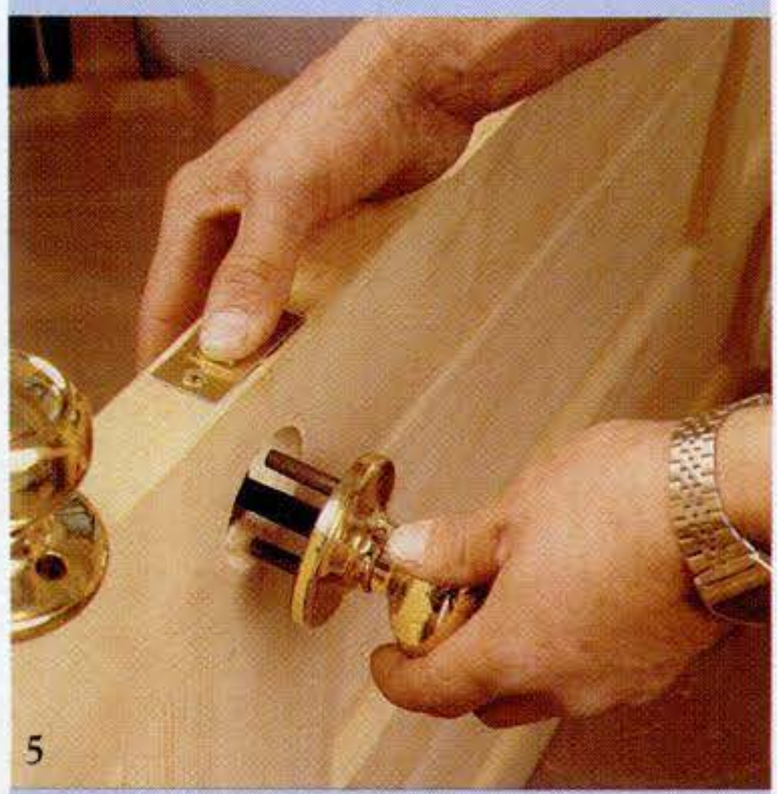
Kwikset has prepared complete, detailed installation instructions for entry model locksets. The procedure is identical for privacy, closet and exit models in any design. Shown here is an exit model door by Wing. Take your time and follow the Kwikset directions exactly.



1. About 36 inches from floor, mark center hole on door face through guide or template for 2⅜", 2¾" or 5" backsets.
2. Drill 2⅛" hole through door face as marked for lockset, drilling from both sides.



3. Drill a 1" hole in center of door edge for latch, checking template for correct latch size.
4. Install latch in hole, parallel to face of door, mark outline and remove latch. Chisel until latch is flush with edge.



5. After installation of strike, with hole in jamb a full ⅝" deep, install exterior knob. Make certain stems are properly positioned through latch holes. For easier installation, depress latch bolt. Install mounting screws.

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How to greet your guests in style.

If there's one finishing touch that's noticed more often than any other, it's the locksets on your doors. That's why you should see the full range of decorating choices from Kwikset.* Each one offers the quality and value that has made Kwikset the largest-selling residential locksets in America. And with all those beautiful styles and finishes to choose from, you're sure to find exactly the right choice for every door in your house.

*Limited time $1 value, FREE–16 page idea booklet for dressing up your doorways. Write Kwikset Corp., Box 4250, Anaheim, CA 92803-4250.

EMHART

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take care of the major jobs, such as structural and concrete work, new walls or flooring, roofing, framing, gas, electrical and plumbing work. There's still room for building "sweat equity" by spending your own time and effort on projects that you can do yourself.

The removal, or demolition process is one such job. A homeowner could have done much of this kind of preparatory work for our *Popular Science* house, readying it for remodeling. A good idea is to work with your contractor so that he can give guidance on what must be done, in what order, and whether or not he feels you can do any of the tasks yourself or whether it would be better to have one of his workmen do them.

Installing gypsum wallboard; laying ceramic tile; installing basins, sinks and some appliances; paneling; installing insulation, and many other tasks are comparatively easy to do and can make important cost-cutting contributions. Certainly painting comes to mind for do-it-yourselfers who are willing to invest time and work. See the detailed helpful information on both interior and exterior painting elsewhere in this section.

Bids and Estimates

A rapidly growing trend in all phases of the construction industry, including remodeling, is towards computer-aided takeoff and estimating systems, which permit the user to draw plans, provide quantities and price the project concurrently. Techsonix, the originator of such systems, is featured later in this section. The Techsonix Digitizer System is used to take off quantities from the plans and to prepare extremely accurate cost estimates using computer technology. The resulting printout also serves as a checklist for agreement on products, projects and pricing. Darcy Messina is an extremely strong advocate of computerized takeoffs and estimates, believing that they protect both the homeowner and the contractor.

Get a contract with a written estimate detailing what's to be done, when, by whom and for how much. Leave nothing to chance. The agreement should describe the project, materials, timetable or schedule, the cost and when you are to make payments. You'll probably have to advance part payment (20 percent perhaps) for start-up labor costs, but hold back part of the payment until the job has been satisfactorily completed. A verbal agreement is not enough.

On complicated jobs and when specifications or plans cannot be locked into place, it may be fair to both parties to use a "cost plus" arrangement that marks up the labor, materials and other factors by a percentage. It should have a "cap" or maximum allowable. If only one job at a time is involved or if your plans are detailed and not likely to be changed, you probably will be able to get a firm bid.

Pickup is "Handyman's Helper."

Our remodeling contractor found many uses for the versatile Isuzu Spacecab LS Pickup. One was for moving debris during the demolition process, shown in the photograph above. The Isuzu Spacecab LS is a tough, versatile, hardworking partner and one which the contractor and his crew quickly learned to appreciate in picking up various tools and products.

As part of a new generation of Isuzu trucks, it's all-new all over, from the sophisticated I-TEC (Isuzu Total Engine Control) fuel injection system to the easy-opening quarter-vent windows. When you hit the gas, you'll be pleased to find lots of power under the hood, with 25% more horsepower and 19% more torque than last year.

The Spacecab LS model is especially comfortable with reclining bucket seats, retractable cargo cover and a 4-speaker stereo/cassette. Jump seats face forward for passengers comfort.

One of the pleasant surprises was the many ways we who are working on this project used the Pickup. In one week, we logged more than 800 miles on interstates and back roads, without ever tiring. Four of us once shared a comfortable and enjoyable 60-mile journey back and forth to dinner. The service-oriented Isuzu people in Atlanta were exceptionally helpful.

The Isuzu Pickup came in very handy for running errands to the building supply and hardware stores, for products like Owens-Corning Fiberglas® Oakridge architectural shingles. Our workman in the photo is wearing Dickies pants, shirt, and jean jacket and his Georgia work boots.

How Home Improvements Rank as Resale Investments.

Recent remodeling industry reports state that many of the improvements that make a house most comfortable and most livable are also those which generally add the highest percentage of their cost to the resale value of the home:

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You can take shortcuts. Because we didn't.

Before you leave the road in any 4x4, better compare how your 4x4 leaves the factory. Because ours is built around a steel frame reinforced by 6 rigid cross-members, assembled with over 3,000 rattle-proof welds and protected by not one, but six coats of anti-corrosion finish.

But our 4x4 doesn't just survive the wilderness, it lets you enjoy it. Thanks to the only four-wheel disc brakes standard on any compact pickup truck, power steering, an advanced suspension system and an engine so powerful it turns our 4x4 into what *Off-Road* magazine calls "a rocket!" and "a delight off-road."

4x4 Pickup $10,579*

So maybe you should take a shortcut of your own.

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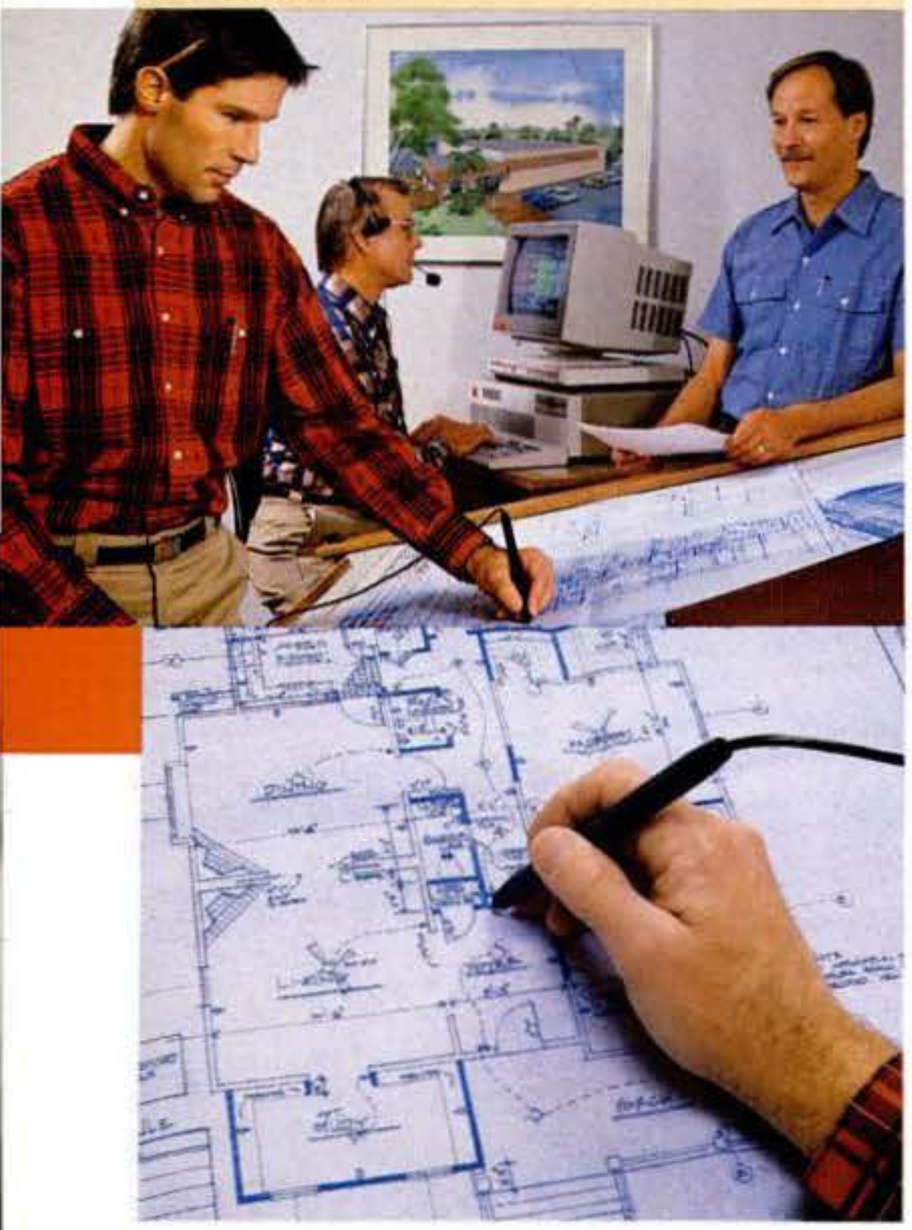
To your Isuzu dealer.

ISUZU

The First Car Builders of Japan.

*M.S.R.P., P.O.E. excluding tax, license and transportation fees as of 11/30/88. Optional equipment shown.

Top: the estimator has fed all pertinent information into the Techsonix System and is using the Master 2000C program to consider options. Bottom: he's digitizing the plans with his stylus, entering important data. The computer in the background will generate accurate takeoff figures and estimates.



Computerized Estimates Hailed.

Darcy Messina, our remodeling contractor, is a staunch advocate of new computerized takeoff and estimating systems, declaring that they benefit both contractor and customer.

One of the pioneers in this kind of estimating system was Marsh Racin, a general contractor, professional estimator and instructor of construction law. He used his 30 years of construction experience and his understanding of the need for quick and accurate cost estimates, takeoffs and quantity calculations to create the Techsonix Digitizer System, a state-of-the-art system recognized by building materials dealers, builders, architects and engineers as a technological masterpiece for the construction industry.

The most recent advancement from Techsonix is the Master 2000C program. In addition to measuring lengths, heights, widths, volume, angles, weights and depths, it also allows the user to branch, use conversion tables, round up, attach memos, image the plans on the monitor, take off and estimate in both metric and conventional scales.

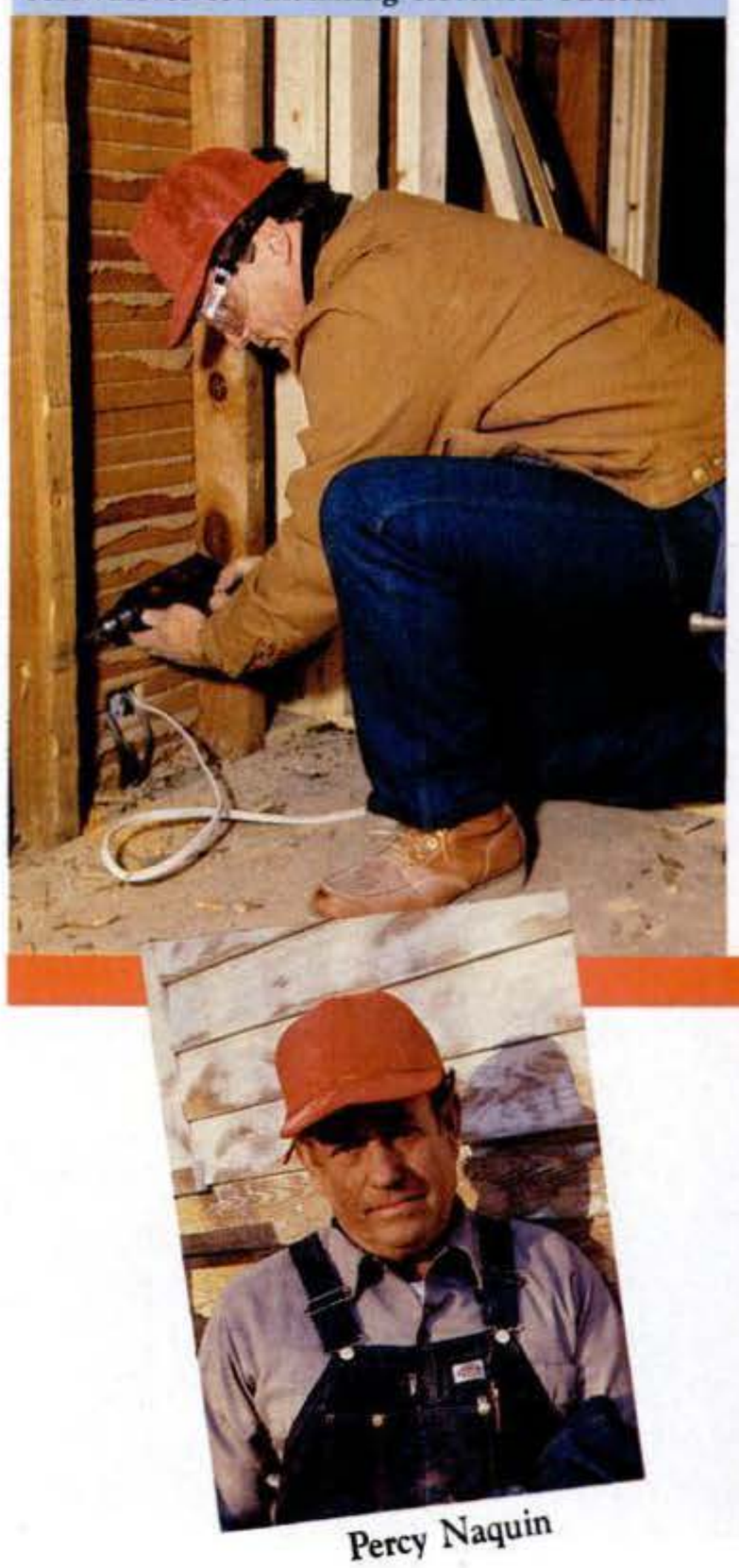
Power Tools: Important Project Partners.

Its inconceivable today to think of doing a major renovation project without power tools. They now help us saw, drill, hammer, sand, stir, pulverize, cut, tamp and polish better and easier than ever before.

We found Percy Naquin, the general foreman on our remodeling project, to be an interesting person to talk to about power tools. He was very happy when Skil Corporation sent us a 7¼" #5656 Skilsaw™ Circular Saw and their ⅜" Professional Cordless Drill for use on the project. Percy, in 35 years of construction work, has used almost all of the brand-name tools and he was quick to say he has been buying Skilsaw because "they last longer and the blade doesn't get wobbly like some others." The Skilsaw also features an exclusive, remote lower-guard lift lever that ensures convenient, easy lower-guard retraction when making pocket cuts. Another feature that Percy appreciates at the end of a hard day is the saw's new high-strength, extra-wide, lightweight steel foot. This model also stores the blade wrench right in the handle. No more lost wrenches!

When Percy tried Skil's Top Gun™ #2735, he found it "very handy," particularly in remote areas where even a long cord has trouble reaching. He also liked the comfortable feeling that the pistol-grip styling gave him. The Professional Cordless Drill has a machined chuck, specifically designed to give maximum bit retention. It has a 12-volt battery pack for utmost power, recharges in an hour, and has a vari-torque clutch with five preselected torque settings. The drill offers two speeds, 1650 RPM for extremely fast drilling and 500 RPM for high torque screwdriving. Percy said "hanging all those new Wing doors is going to be a snap" with this new drill. And he was right.

Below: tough, 80-year-old, full-sized 2 x 4's don't faze a Skil Top Gun™ Professional Cordless Drill. Minutes later it became an equally efficient screwdriver for installing electrical outlets.



Percy Naquin

From the Originator of

COMPUTER AIDED TAKEOFF & ESTIMATING SYSTEMS FOR THE CONSTRUCTION INDUSTRY

TECHSONIX

Now Introduces

MASTER 2000C

Every day—somewhere in the world, millions of dollars of accurate construction estimates are being completed by Techsonix customers. **Are they your competitors?** . . .

And now, they can do it even faster and more accurately than ever before with the Amazing MASTER 2000C program.

TXS/CAD

The Ultimate computerized **DESIGN**, Takeoff & Estimating program . . . **DESIGN IT** . . . **QUANTIZE IT** . . . **PRICE IT** . . . All AT ONE TIME. The program interfaces with Auto/CAD* which enables the user to draw the plans in color as before, but now provides quantities and costs concurrently.

Techsonix is pleased to have been selected by Popular Science for participation in the "Win This Home" Sweepstakes construction project.

Want to learn more? . . . contact the Marketing Dept.:

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That's why they're reaching for the Skil 2503 cordless 3/8" drill/driver. It delivers features professionals demand.

Like a 5-position variable torque clutch to prevent overtightening screws. Two-speed trigger switch. A built-in 7.2 volt battery pack that recharges in an hour.

All at a price that's as comfortable as its feel. Even for serious do-it-yourselfers.

For a decidedly superior cordless drill/driver, the Skil 2503 is precisely the right choice.

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Workman uses Skilsaw™ to cut APA plywood sheathing on new roof over the great room. Lighter weight of saw reduces fatigue on ladder and climbing jobs. Note Dickies work jacket and jeans and Georgia Boots.

Demolition Took a Dusty Week

The walls of our house were covered with wood paneling some years ago. It had held up well, but it darkened the interior. We decided to remove the paneling and most of the plaster it had concealed. We also removed some walls and the kitchen and bath floor covering.

All of this work was done with traditional tools, plus the Red Devil Slammer Scraper, which was designed for floor-covering removal but also worked surprisingly well for plaster removal. Plaster, lath and studs were wheelbarrowed to the back yard, followed by the kitchen cabinets, sinks, bathtub and commode. All the debris was then removed with our Isuzu pickup and larger trucks from a local hauling company. This took three men a week. The house interior was then ready for the construction of new walls, wiring and plumbing.

Note: Some of these demolition jobs could be done by a vigorous D-I-Yer but should be approached with respect for the dust and violence of the process. If you and your contractor decide that you will participate, wear work gloves, a hard hat, safety boots and goggles and use disposable face masks.

The Roof: a Top Priority

If the roof needs to be replaced as a part of a project, it should be one of the first jobs scheduled, because new interior work could be ruined by a leaky roof or a roof

THE NEW OLYMPUS INFINITY SUPERZOOM.

IT'S SO REVOLUTIONARY, THIS IS THE ONLY SIDE-BY-SIDE COMPARISON WE COULD MAKE.

You've never seen anything quite like it. There's never been anything like it. Not an SLR. Not a point-and-shoot camera. In fact, it's not even like putting the two of them together.

The Olympus Infinity Super-Zoom just may have the most revolutionary technologies ever designed into a 35mm camera. Yet, it's so small, so light, so easy to use, it can be held and even operated with just one hand.

It has the world's first built-in, autofocus 38mm to 105mm power zoom lens. That makes its telephoto capability much greater, bringing your subject far closer, than any other 35mm compact zoom camera.

Not only that, the viewfinder zooms too, right along with the lens. So you always see just what the camera is seeing. And because there's an entirely new kind of optical system at work here, your image won't be blacked out when you press the shutter, something that happens every

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that's opened during construction. The roof at the Madison house was in fair shape. It had gable, hip and shed elements, covered in asphalt shingle and tin with metal flashing. Some sagging was noticeable from the front and right sides. The prior owner, who worked in the construction business, had reshingled the roof over 15 years ago with a 20-year-rated product. Because the shingle was that close to the end of its likely life-span and because the roof needed other repairs and bracing, we decided to proceed with a new roof.

We removed the old shingle, then covered over the old tarpaper with a new layer before applying new Owens-Corning Fiberglas® Oakridge architectural shingles. Sagging roof members were braced from the inside and rotted wood replaced along the roof edge in several areas. So that the new Raingo™ gutter system would extend beyond the roof edge, we added two-by-fours to the fascia. The rear porch tin roof was removed and the roof was extended and sheathed with APA plywood, then tarpapered and shingled, along with the new breezeway and garage roofs.

Unique Camera Design Offers Effortless, Multi-Automatic Shooting.

A world of imagery can be at your fingertips as you take pictures in perfect freedom with the Infinity SuperZoom 300 camera by Olympus. This exciting new camera, offering unique handling and a built-in, extended-range zoom function, is what the future of photography is all about. It's appreciated by professionals such as Stuart Gross, the New York-based photographer who is shooting all three *Popular Science* Home Remodeling Guide special sections. In the photo at right, Stuart uses his Olympus for a photograph of the roofer installing Owens-Corning Oakridge® architectural shingles, using an Arrow HT-65 Extra Heavy Duty Hammer Tacker. It was also part of the Handy Househunting Kit used to record both interiors and exteriors of some 50 homes.

Before you start remodeling, whether it's renovating your present home or one you're moving into, consider making a record of the "before" in a series of photographs. We did it in order to show you the "befores" and "afters" in these special sections and recommend it to you as a way to preserve for posterity what the house was like before you invested your time, money and work in creating your dream home.

It's very easy to recommend the Olympus Infinity SuperZoom 300 camera because it's so simple yet sophisticated. It's one camera that does it all, does it better, and does it easier. It can zoom automatically in two portrait composition modes. Extremely fast automatic focusing is also ex-

tremely easy with programmed auto exposure and AF illuminator for low-light precision. The built-in automatic flash has multiple modes.

It doesn't stop there. Film handling, from loading to rewinding, is fully automatic. It was the first full frame 35 mm camera to incorporate power zoom to over 100 mm in focal length. Power zoom in, power zoom out. As you zoom, keep your eye on the finder and you will always see precisely the view you're going to get on film. And while you're zooming, the auto exposure program changes to assure the finest choice of aperture and shutter speed for every picture angle.

In designing the Infinity SuperZoom 300, Olympus tossed conventional camera concepts aside and concentrated on an entirely new concept. The result: a new level of total performance in an all-new camera. Drop in the film and close the back. That's it. You're ready to shoot. The camera makes you a push-button professional.

me with an SLR.

What's more, this auto-everything wonder comes with the smallest, most versatile, multimode zoom flash ever available.

But that's not all. There's our innovative autozooming dual portrait mode, spot metering, double exposure; you can shoot continuous action sequences and even use special effect filters, all with the built-in, extended range zoom lens.

And for all this sophistication, you don't need an engineering degree. All you need to be able to do is push a few buttons.

Side by side, no other camera, compact or otherwise, can compare itself to the incredible Infinity SuperZoom. Of course, you can reach that same conclusion when you visit your Olympus dealer and see it for yourself. Face to face.

OLYMPUS®
Focused on people

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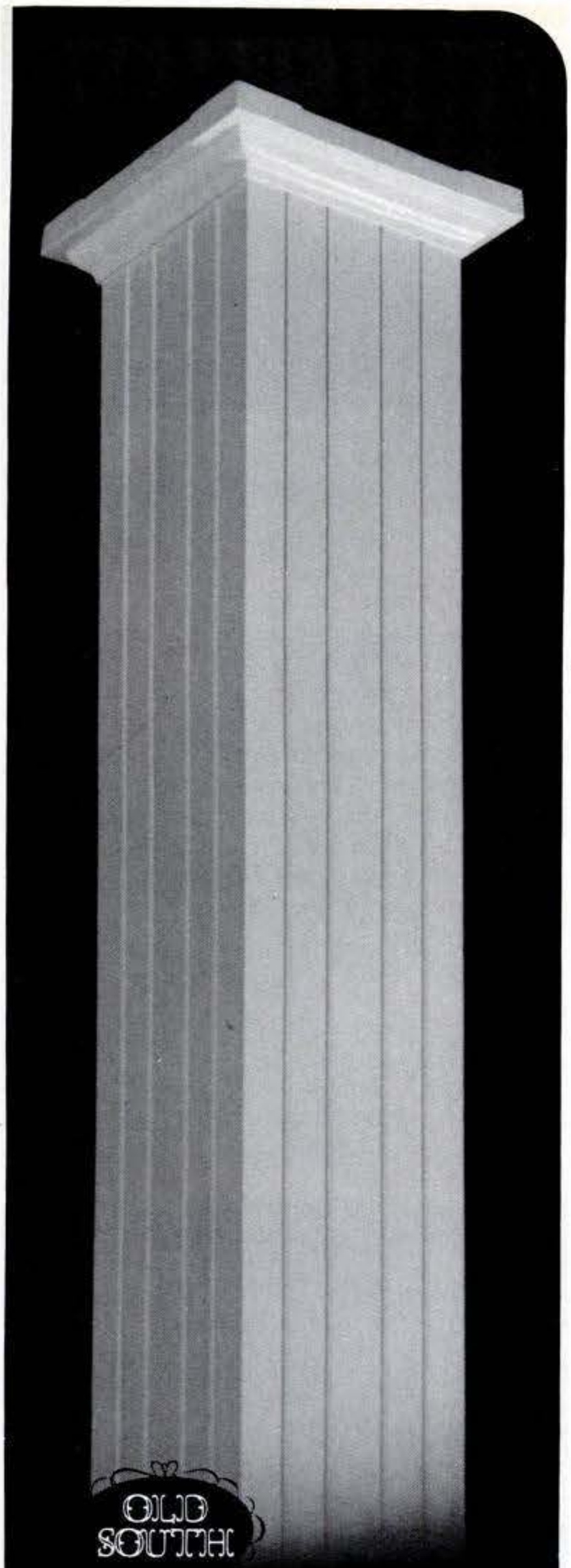

Square Colonial Columns

In Durable Aluminum

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New Railings Add to Beauty of Columns.

A major feature of the remodeled home in Madison will be Old South aluminum columns, replacing wooden porch columns that were badly deteriorated. The traditional elegance of the porch is being perpetuated in aluminum columns, which are far stronger than wood, are easy to maintain with very little trouble or expense, and resist weathering, insects, warping and dry rot.

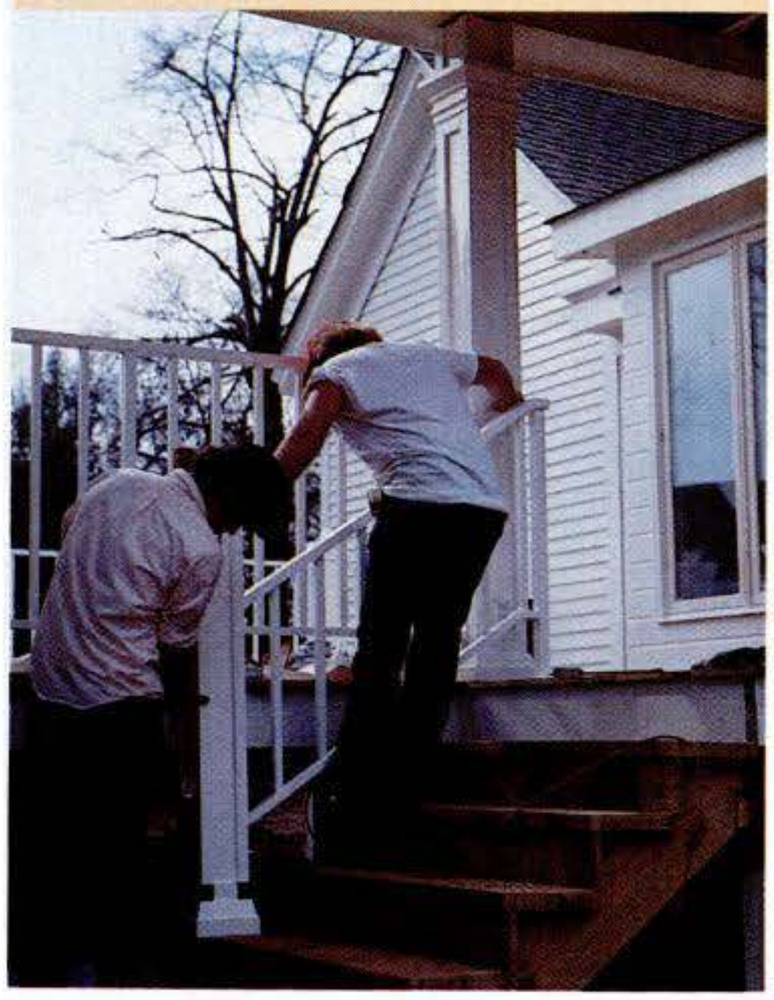
In designing the front elevation, Zoe Van der Cleveland decided to connect the columns with another product made by Moultrie Manufacturing: Old South aluminum railings. These railings can be attached with angle clips to Old South architectural columns, with little effect on their load-carrying capabilities. In installation, the hardware is bolted to the columns at special notches and cutouts.

There were both practical and esthetic reasons to specify Old South railings. They have the same resistance to deterioration as the columns because they're also manufactured of tempered extruded aluminum. The decorative beauty comes from the unique custom design of the railings, which enhances the grace of the columns.

Moultrie also has beautiful custom-designed panels, gates and fences, that combine beauty and security. Picket fence, single and double oak design, shell, rose, circle and grape are a few of the panel designs, while stunning driveway gates and fences can also be made to the specifications of builders and designers.

A word of warning about all custom-made building products, such as Old South columns and railings: be very, very careful in your measurements. If you have the smallest doubts, contact the manufacturer for clarifications. Even a small mistake can render the new item useless, so measure precisely.

At the rear of the house, workmen are installing made-to-measure Old South aluminum railings. Square Old South columns, behind them, add elegance to the breezeway.



Avoid Future Problems by Taking a Good Look at Your Roof

A simple inspection of your home's physical condition may reveal problems before they become serious. For example, according to Timothy Walsh, vice president of marketing for roofing products at Owens-Corning Fiberglas® Corporation, a close look at your roof now can prevent costly repairs later.

A roof inspection, or audit, will not only help protect the value of your investment in the home, but will also ensure the overall safety of your home.

A few simple steps can help homeowners evaluate the roof's condition, using only a ladder, Mag® flashlight and binoculars.

Start at the top, where the roof should form a water-tight shield. Check the roof carefully for water leakage.

Stand back from the house and look carefully through your binoculars for lifted, torn or missing shingles. Keep an eye out for shingles that are curled, blistered or that look shiny, and look for balding shingles that are losing their protective coat of mineral granules. Look for damaged flashing and keep an eye out for cracks or gaps.

Inside, use a flashlight to check your attic for water stains around the corners and under rafters. During a storm, check for interior leaks, water marks, drips or other signs that water is infiltrating.

Five Tips for Putting on New Shingles.

1. If you uncover a serious roof leak, it may be time to consider putting on new shingles. Before you do so, contact a roofing contractor so that he can make a more thorough inspection of the roof and explain your options.
2. Take care of repairs as soon as possible to avoid any serious damage.
3. Check the new shingle warranty carefully. Length of coverage and reimbursement costs do vary from one manufacturer to another.

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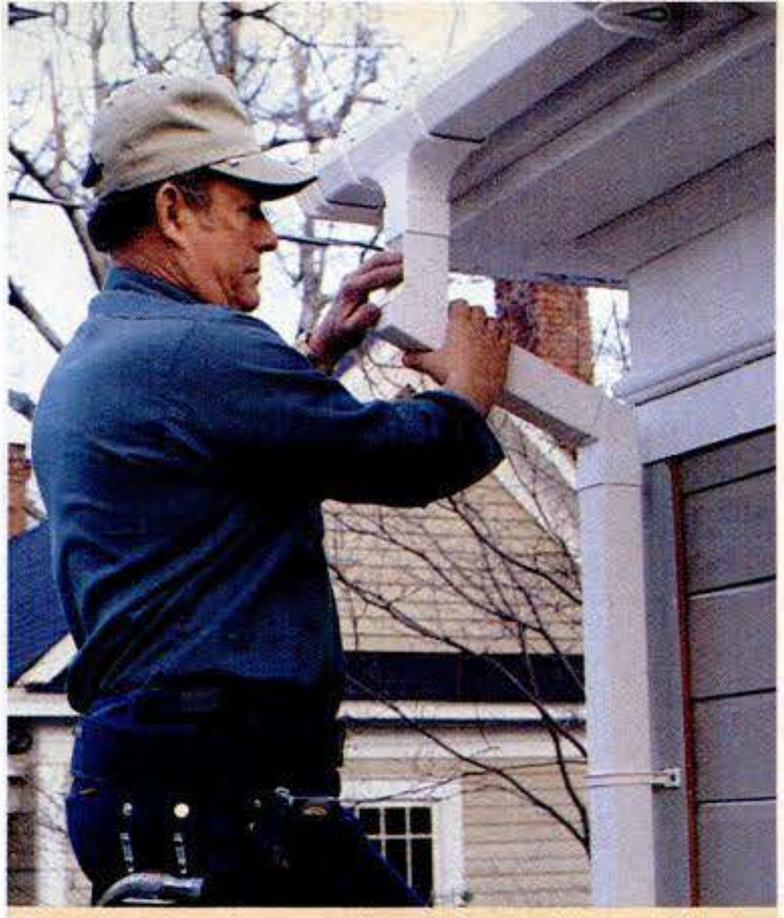
4. Shop for durability. Organic-base shingles typically carry a 15-year warranty, while glass-fiber shingles, usually more durable because the inorganic-base mat won't absorb water, typically have at least a 20-year warranty and sometimes even 30-year warranties.
5. Look for fire-resistance ratings on the shingles. Most organic-base shingles carry an Underwriters Laboratories Class C rating, while most glass-fiber shingles carry a Class A fire rating—the highest in the industry.

A new roof may not be the answer, the Owens-Corning Fiberglas® spokesman readily acknowledges, but he cautions that you should take care of roof repairs as soon as possible to avoid serious damage, especially to your furnishings and other expensive items inside your home.



Following the simple, helpful advice in Genova's do-it-yourself "Raingo™ Roundup" guide, we used only common tools to install nearly 500 feet of Raingo™ gutters and downspouts, Highflo™ Drop Outlets and Leafgo™ Debris Separators, turning 40 corners. An excellent D-I-Yer project.

Outstanding Gutters and Downspouts Deserve Better Name Recognition.

Often an industry leader becomes better known by brand names than by its own corporate name, but somehow we just didn't expect it with do-it-yourself remodeling products. Here's a true story.

The gutter and downspout supplier for the *Popular Science* remodeled home is Genova Products, a leader in building materials. With basic rain-carrying equipment ready for installation, we needed a couple of their items for photography. We began calling nearby home center and building supply outlets, asking if they carried the specified Genova items in stock. Told "no," we asked what other products the retailer would recommend and found that three trade names were regarded as absolutely superior. They were Raingo™, Highflo™ and Leafgo™. These three well-known trademarks share common identities: They are all products in the Genova solid PVC vinyl gutter and downspout systems. And they are all known as the best available.

We found that the Raingo™ Solid Vinyl Snap-Together system, manufactured by Genova, has eliminated many major gutter installation problems. A complete system, its few parts snap together easily with no adhesives or sealants, and only a few common tools are required.

The Genova system is more durable than competing metal systems. It will not rust, rot or corrode, and never needs painting. Exclusive Raingo™ ridges reduce buildups while the design of the Highflo™ Drop Outlet creates a powerful vortex that draws water and debris towards the downspout area. When the water is flowing down the drainspout, the Leafgo™ Debris Separator permits the water to pass, but screens out leaves and other "cloggers."

It is a great system, whether it's known as Genova or by its individual brand names. Installation is easy, and helpful literature for do-it-yourselfers is available at Genova-Raingo™ retailers or from the company.

Leaky Gutters Are For The Birds.

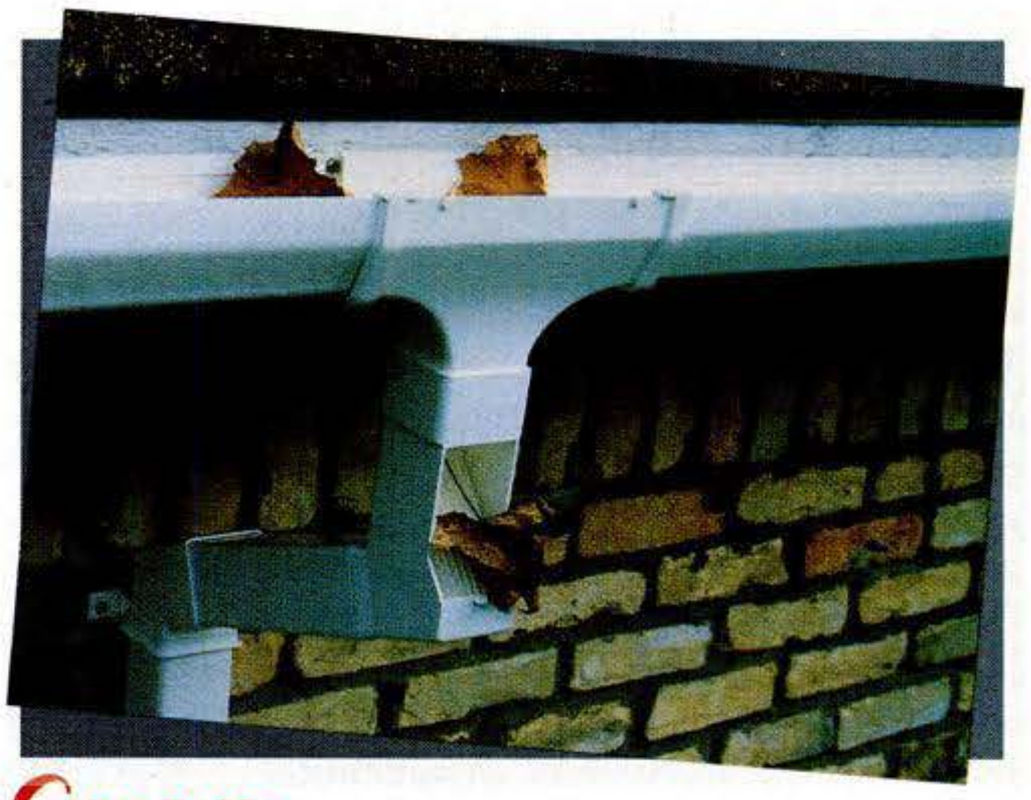
Buy Raingo™ and stop swimming in your troubles.

RAINGO™ is the solid PVC gutter system that is durable enough to withstand years of use and abuse by nature's elements.

This easy "snap-together" system can be installed by only one person.

No maintenance required! RAINGO™ gutter systems feature RAINGO™ RIDGES which in combination with HIGHFLO™ and LEAFGO™ make the system self-cleaning.

MADE IN THE U.S.A.



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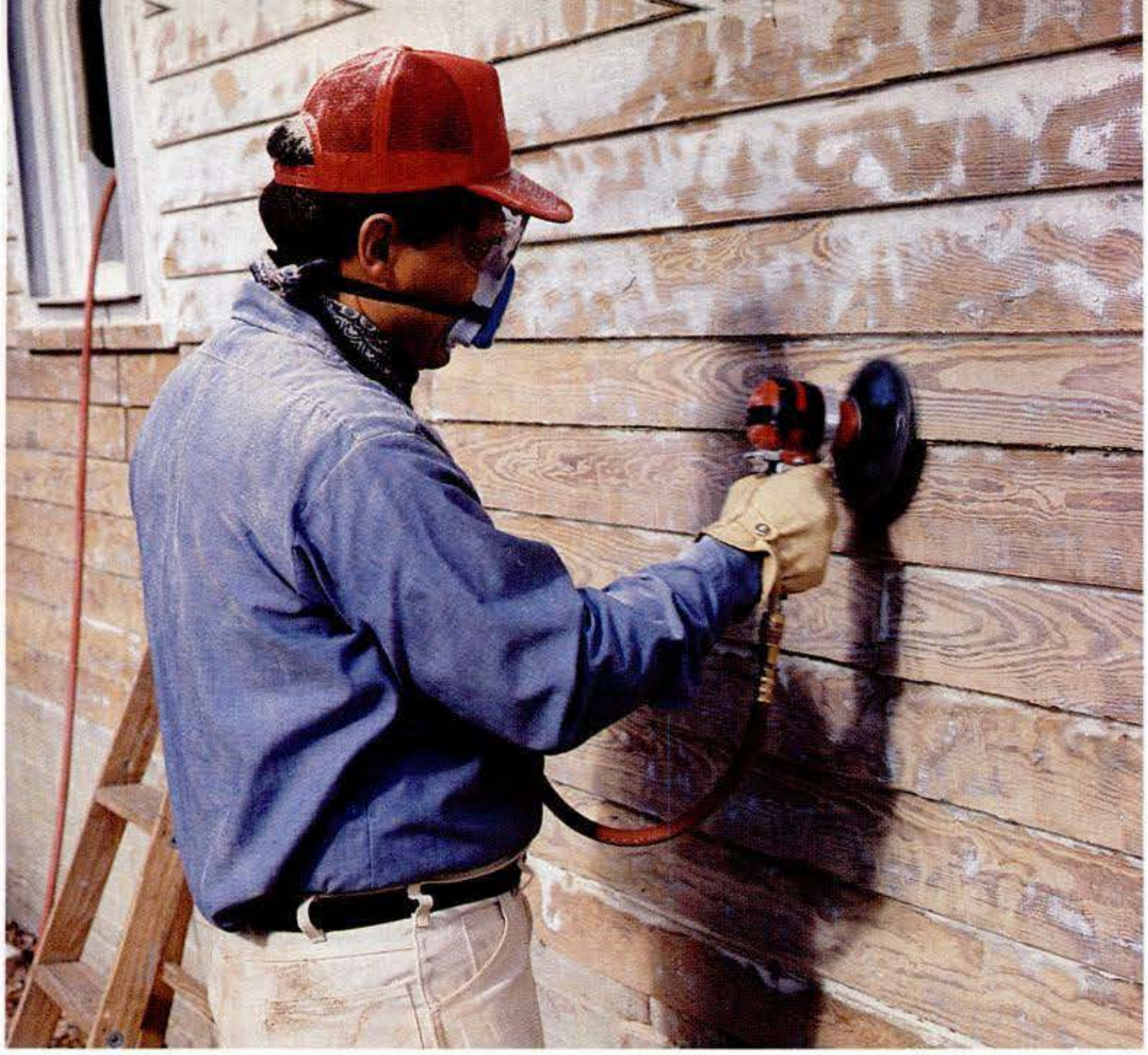


Our painter, properly protected, sands off the siding surface. Goggles and a face mask are obvious necessities. Dickies™ painter pants, shirt and gloves complete his outfit.

Seven Steps to a Great Finish

In the first section, we reported that the exterior of our 90-year-old home, as you might expect, had extensive peeling and cracking of the paint, plus areas that needed structural repair.

When our working crew began surface preparation, they knew from the experts at Olympic® Paint and Stain Company what they should do about the house. Getting a surface ready to paint takes a great deal of time, patience, careful attention to detail and old-fashioned sweat. Ask our Madison painters about the days and days they spent making sure the surface was clean, dry and sound.

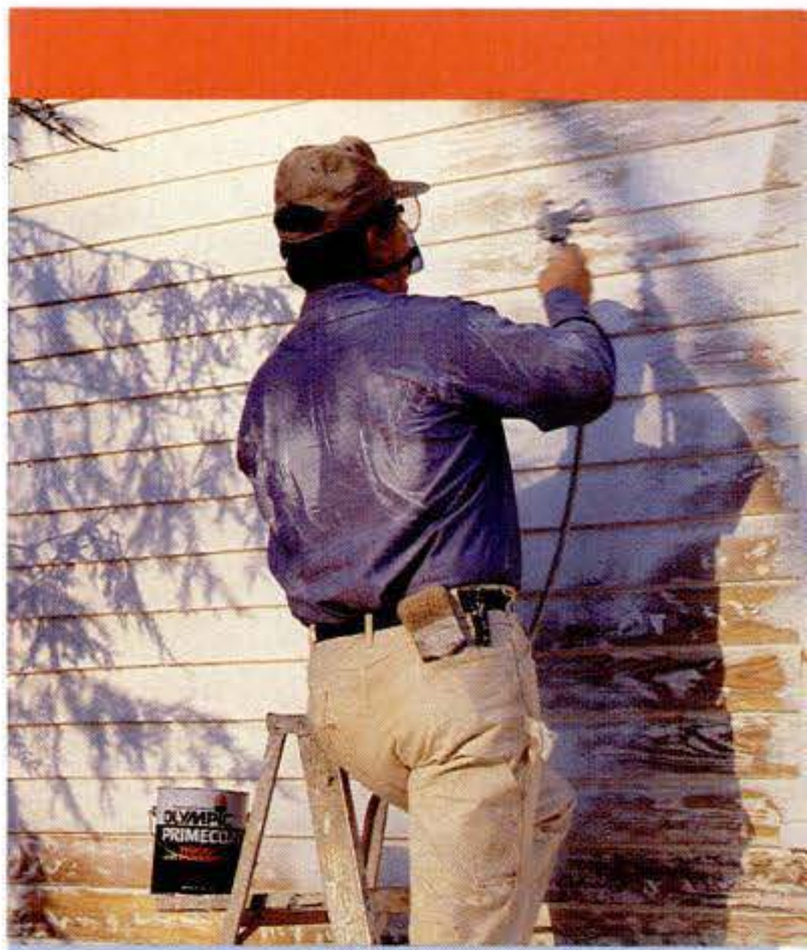
Proper preparation includes making sure that the surface to be painted is completely free of surface mildew, dirt, chalk and existing paint that has blistered, cracked or broken loose from the siding.

You'll be ahead in the long run if you follow these seven steps from Olympic:

1. **Analyze the project.** Is it time to paint or stain? If you apply a new coating just before it is really needed, you can avoid excess surface preparation and application labor. Then when you do decide to recoat, walk around the building looking high and low for things that need to be corrected before you start.
2. **Repair structural problems.** Isolate problems caused by moisture. Install ducted ventilation fans or special siding vents if they're needed, to allow inside moisture to escape. Fix or replace ripped or rotting siding, masonry cracks, missing caulk, popped nails, rusty metal and leaky or leaf-filled gutters.
3. **Remove loose coatings.** If cracking, peeling or blistering has occured, all loose coating must be removed by scraping, wire brushing, sanding, high-pressure water blasting, etc. All rough edges should then be sanded and/or feathered. If you're repainting, be sure to prime any bare or exposed surfaces as directed in Step 6.

   Caution: Wear safety goggles when removing paint or stain. When sanding, wear a dust mask in addition to the goggles. Follow manufacturer's directions when using high-pressure water blasting equipment, which can be dangerous if used improperly.
4. **Clean the surface.** All wood surfaces, new or old, should be clean and dry before a coating is applied. Remove surface dirt by washing with a solution of one cup of detergent in one gallon of warm water. (Tip: It is easier to use a hose with a car-wash brush attachment.) Apply the cleaner to only part of the surface and rinse completely with clear water before you move on to another area. Allow the surface to dry thoroughly before applying paint or stain.

   Caution: Follow manufacturer's instructions when using cleaning agents, many of which can be potentially harmful to your health. Use protective clothing, eye goggles and good rubber gloves.
5. **Treat problem areas.** Some areas may require special care. Remove mildew by scrubbing with a solution of one cup of non-ammoniated detergent and one quart of household bleach dissolved in three quarts of warm water. Rinse thoroughly with clear water and allow to dry. Glossy areas should be lightly sanded. Also, sand off any grade stamps or pencil marks from new wood surfaces if you plan to use semi-transparent stain. Brush new, rough wood to remove all loose fibers before painting or staining. Again, follow manufacturer's instructions when using cleaning agents, and use protective gloves and goggles.
6. **Prime bare wood, masonry and metal.** Any bare wood, including the small spots you've scraped, should be primed with Oil or Latex Primecoat™, especially when used over redwood, cedar, mahogany, fir and other woods prone to extractive bleeding. There are specific preparation and application instructions for surfaces such as metal, hardboard and masonry. Because of the specialized nature of these surfaces, we recommend you talk to your Olympic dealer for proper preparation and application recommendations.
7. **Choose the right Olympic product.** There are Olympic paints and stains for many kinds of applications, such as repainting, restaining and use on a variety of new wood surfaces and non-wood surfaces. You'll get the best results when you select the right Olympic paint or stain to meet your particular surface coating needs. Again, if in doubt, ask your dealer for his advice and help.



After sanding, Olympic Latex Primecoat™ was applied and allowed to dry for 24 hours. See how Olympic Outside White Overcoat® provides a handsome finish in the third section, which runs in June.

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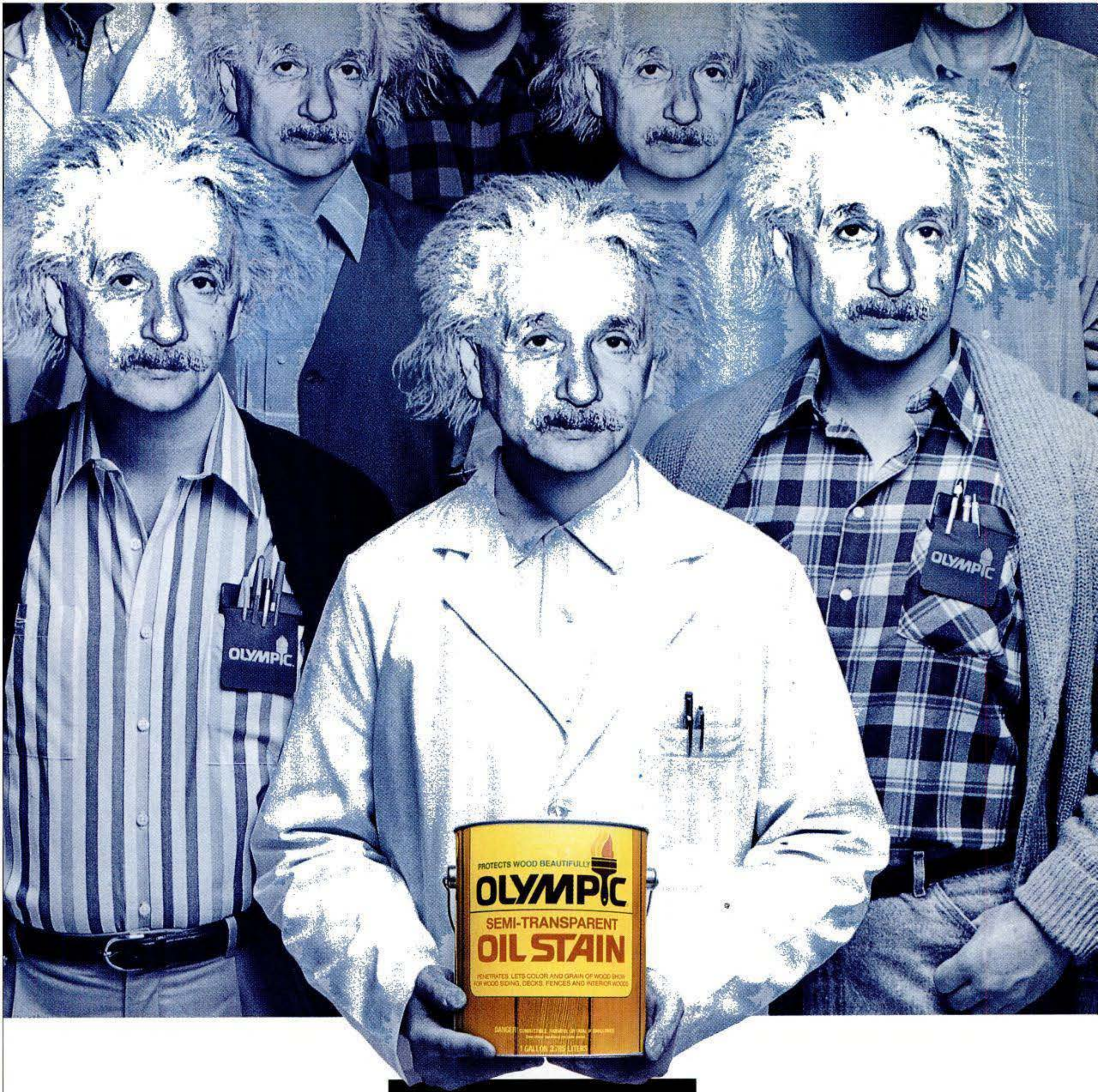

For openers, the great minds in our labs have developed oil stains with a special combination of protection and good looks. We start with 100% pure linseed oil to penetrate and reinforce wood fibers. Then we protect the wood from weather and enhance its beauty by adding micro-milled color pigments. So it's smart to use Olympic. Even better, our dealers have the understanding and know-

THERE'S A LOT OF THINKING BEHIND EVERY CAN OF OLYMPIC OIL STAIN.

how to help make your staining project a success. They'll advise you on how to prepare the surface, pick the right product and get great-looking results. So there's a lot behind Olympic. A lot of it very scientific. And a lot of it very human, too. So go see an Olympic dealer. These guys are smart.

OLYMPIC

Albert Einstein Licensed by the Roger Richman Agency, Beverly Hills, CA

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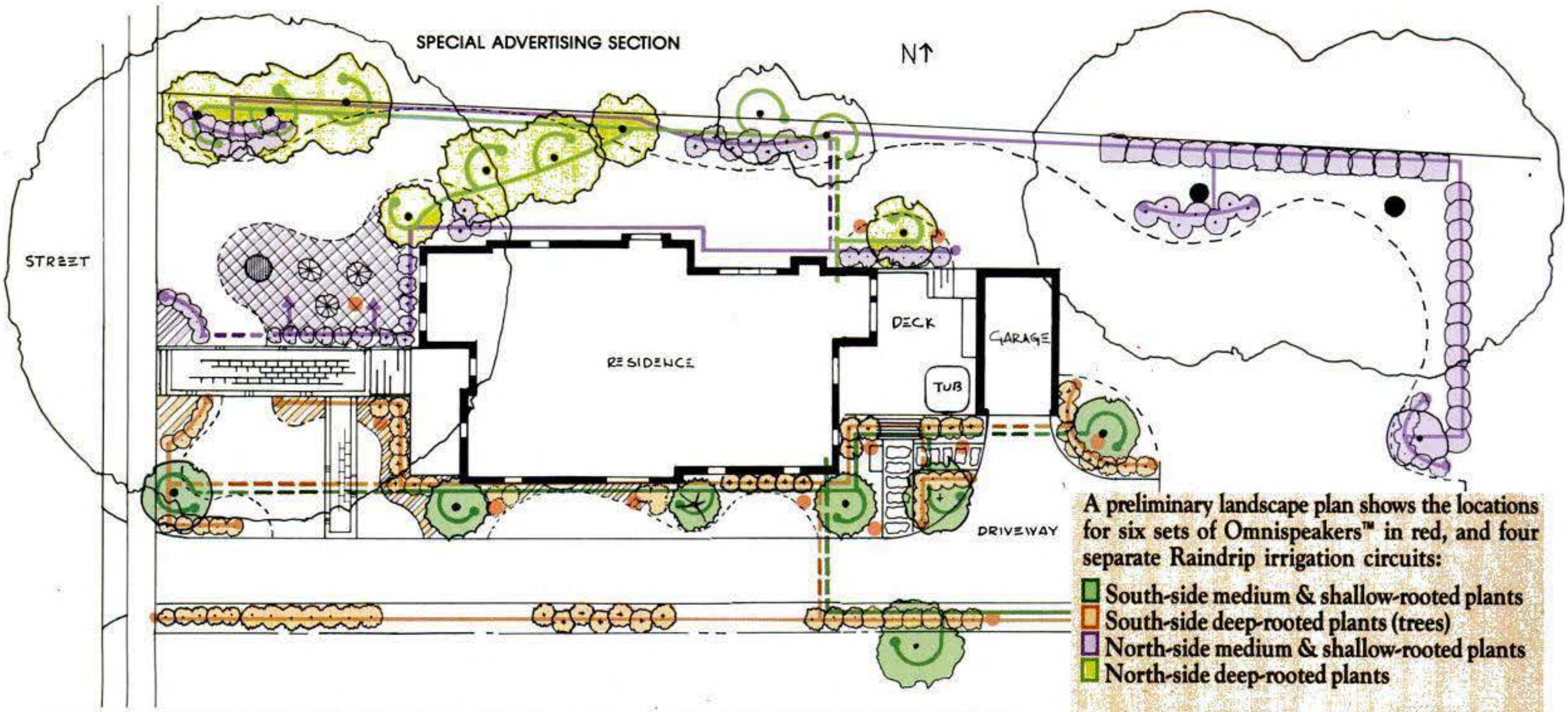

A preliminary landscape plan shows the locations for six sets of Omnispeakers™ in red, and four separate Raindrip irrigation circuits:

- South-side medium & shallow-rooted plants
- South-side deep-rooted plants (trees)
- North-side medium & shallow-rooted plants
- North-side deep-rooted plants

Are You Ready for the Latest in Watering Systems?

If you're thinking of moving from watering can to watering system, you should consider drip irrigation. The concept is simple. The slow, regular delivery of water directly to the base of a plant produces deep penetration that keeps the root zone moist, never saturated. The system has been proven to produce faster growth and greater yield while reducing water usage because there is no puddling, run-off or water lost to evaporation—you put water only where needed. That means dollar savings. Plants grow as much as 49% faster. Also, fewer weeds are germinated between plants and plant rows, and because no water hits the leaves, there is less chance for foliage disease to develop.

Raindrip® has a kit for every application. They are simple to install and work on any container plant including hanging baskets, hedges, trees, shrubs, vegetable and flower gardens, and ground cover. Kits can be buried or left on the surface, year-round, as you desire. Once the kit is installed, it can be expanded with Raindrip's full line of parts and accessories. You'll spend only a few minutes a week on watering, yet your plants will receive just the right amount of water at just the right rate, avoiding the "drench and dry out" cycle. Fruit and vegetable gardeners have reported results of up to 84% larger yields.

The Raindrip drip watering system will be shown in place in the June special section. Raindrip's unique pressure compensating drippers deliver uniform flow from each and every dripper, regardless of water temperature and supply pressure, even on hillsides. These turbulent flow drippers will remain clog-free, and the Raindrip system carries a lifetime warranty on the complete product line.

But that's not the end of the news about watering. In the June issue, we'll also be showing how you can have your watering done automatically, day or night, whether you're at home or away. The RainMatic model 2000 electronic controller provides the brain power to give you up to four watering cycles a day for whatever length of time you need. It's as easy to use as a push-button phone, comes completely assembled and operates on four long-life flashlight batteries for six or more months. RainMatic products are made by a different company, but work well with the Raindrip irrigation system.

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Add Music to Your Landscape Plans.

If you enjoy listening to music and enjoy relaxing in your garden or on your deck, think about Omnispeakers™ from Paramount Pictures Corporation®.

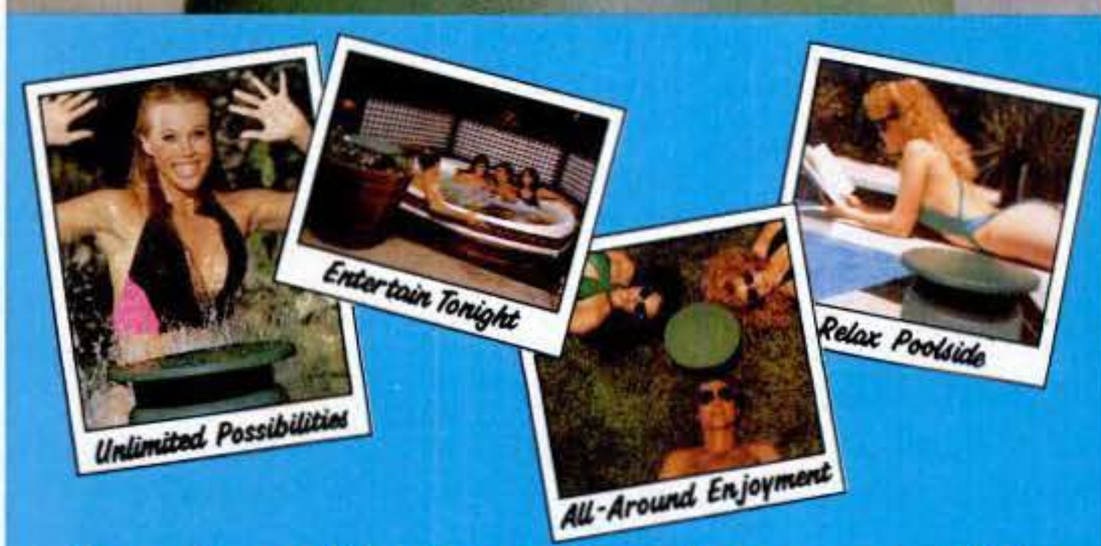
Omnispeakers are an intelligent response to an America that increasingly lives outdoors but wants to enjoy indoor amenities. Our Madison house, with its tilt-windowed Great Room, breezeway and deck with a year-round spa, reflects this new life-style perfectly. Beautiful music, outdoors, is Omnispeaker's unique contribution.

Originally engineered for use at Sea World, Disneyland and Epcot Center, these world-class stereo speakers are fully weatherproofed, soundproofed and, can be planted directly in your yard or in planters. Their landscape-green casings will let them hide around your deck or patio. For the purest sound, place Omnispeaker in the ground. It handles 100 watts of power and projects 360° of great sound. Several speakers properly placed, can bathe your family and friends with a quality of sound you have only had indoors until now.

Each Omnispeaker comes to you with 50 feet of direct burial cable, giving you the flexibility to position a network throughout a garden or around a deck. Very little knowledge about stereo components is required to install Omnispeakers. Connect the Omnispeakers to your stereo and you have complete control over a new sound dimension in an outdoor atmosphere, with music to provide just the right ambience for special moments.

Installing Omnispeakers is an easy project for the D-I-Y homeowner. They are a pleasant surprise to family and friends, and quickly become an important part of your outdoor entertainment activities.

Paramount Pictures Corporation®



Now enjoy quality indoor audio outdoors, year-round! The OMNISPEAKER easily handles 100 Watts of power and has been commercially proven for years at major theme parks, along with some of the finest homes around the world.

Now Available at:

For a retailer nearest you call: 1-(800) 669-0664.

THE OUTDOOR WATERPROOF SPEAKER

OMNISPEAKER™

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Our Madison Yard, and Finding the Right Landscape Architect

How often have you seen a handsome house made ordinary by a plain lot or a modest house made much lovelier by its setting? One of the major assets of the Popular Science house was the yard.

The Madison house is in a neighborhood of generous lots. Our large lot is 85 by 419 feet. City ordinances require 15 feet free of structure along property lines, and our property provides about 20 feet on each side. The front of the house is set back 49 feet from the curb.

Of the existing plant material on the property, we will save: one Burford holly tree, eight dogwoods, privet hedges, one large oak and two large pecan trees. (At one time, the annual county property taxes were paid for by the pecan crop from these trees.) Other plants have either gone "wild and leggy" or are not properly positioned for our plans, and they will be removed.

As the renovation of the house proceeded, we looked for a landscape architect. In Georgia, as in many other states, architects, landscape architects, landscapers, nurserymen and builders all compete for landscape design work. It's important to note that of these only a certified or registered landscape architect is likely to have all the knowledge necessary for a complete landscape project. When you are selecting a landscape architect, check the background and experience of candidates carefully. Ask for references and *use them*. Visit jobs they have done. Find out if the work was completed as planned. Was it on time and on budget? Is the designer's style right for your project? Visit the firm and see if certification plaques, degrees or design awards are in evidence.

After following these guidelines, we chose to work with John Mateyak, President of Environ Associates, a design/build firm located near Atlanta. The preliminary plan he has submitted is shown earlier, with irrigation and outdoor speaker details added. The basic plan is comprehensive and we will complete only portions of the plan at this time. The rest of the plan, plus the remaining 195 feet of the back yard (not shown in this plan), can be done by the homeowner as time and funds permit.

Landscaping is perhaps the most popular of all D-I-Y activities, and all members of the family can help in this highly visible improvement. Work closely with your landscape architect on the project and be sure to discuss with him or her the degree of ongoing care your investment in lawns, plants and gardens will require.

Most Popular Mower Also Big Hit on Our Lawn.

When Honda offered to supply a mower for our Madison property, we left it up to them to select an appropriate model. We described our lawn, knowing that Honda builds a wide range of models to suit specific needs—everything from compact mowers to a durable commercial mower for heavy-duty use. The Honda we arranged to get from an Athens retailer (in our Isuzu Pickup) was described as their "most popular" model—a four horsepower self-propelled mower. It was such a great performer that we were pleased with it and everyone wanted to try it out.

Honda says that there are a few things you can count on in this world: The sun will rise. Rain will fall. Grass will grow. And your Honda mower will always be ready when you need it.

One reason for this dependability is that each Honda model, regardless of size, is built as a complete unit—not just pieced together with parts from different sources. That means that each and every mower sold is backed by Honda's engineering expertise.

Our mower, like most Honda models, uses a Honda Overhead Valve four-stroke engine, which is more oil- and fuel-efficient than the typical side-valve engines found in ordinary mowers. At Honda, low maintenance is a high priority, so their mowers uses durable cast-iron sleeves and ball-bearing-supported crankshafts, plus sealed shaft-drive systems.

We found our Honda mower easy to start (the very first try), probably due to the Automatic Decompression system. The controls were located right in the handle and were easy for our homeowner to operate. Most Honda mowers also feature Roto-Stop™, which lets you stop the mower blade while the engine continues to run, so there's no need to restart the mower each time you stop operation.

Honda mowers are designed with high-vacuum cutter housings for precise cutting and easier bagging.

We learned from Honda about other features of Honda Power Equipment, such as Oil Alert™, which warns the user before the oil level becomes unsafe; thermostatically controlled internal cooling; and accurate mechanical governors that maintain proper engine speed when horsepower demands change.

Honda Power Equipment can make your life a little easier, for years to come.

Homeowners and son pose for lawn portrait with new Honda mower. They're in Dickies clothes and Georgia Boots. She's using an Olympus Infinity SuperZoom 300 camera.

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FOR THOSE WHOSE PERCEPTION OF VALUE IS BASED ON QUALITY NOT PRICE.

The first Overhead Valve engine made starting easier.

To a great many people, the best buy is the one that costs the least. If that is your mind set, there are a number of so-called inexpensive mowers to choose from.

If, however, your idea of value is a bit more far-sighted, there is one choice that stands above the rest: The Honda lawn mower.

Behind this machine are the same engineering geniuses who've built Honda into the world's foremost motor company. Its many innovative industry firsts make it the finest lawn mower money can buy. And, not coincidentally, the first one good enough to be called a Honda.

The first automotive-type shaft drive transmission eliminated maintenance.

The first blade brake clutch that stopped the blade without stopping the engine.

Each of the hundreds of parts—down to the smallest nut and bolt—is meticulously designed by Honda and manufactured to the most exacting tolerances. This control over the entire manufacturing process allows us to assure the quality of every Honda mower. And the satisfaction of every Honda customer.

To learn about convenient financing and Honda's 2-year limited warranty, look in the Yellow Pages, or call the number below for your nearest Honda Lawn Mower Dealer.

The rest is up to you. But remember the old saying, "You get what you pay for."

HONDA
Power Equipment

1-800-426-7701

For optimum performance and safety, we recommend you read the owner's manual before operating your Honda Power Equipment. © 1989 American Honda Motor Co., Inc.

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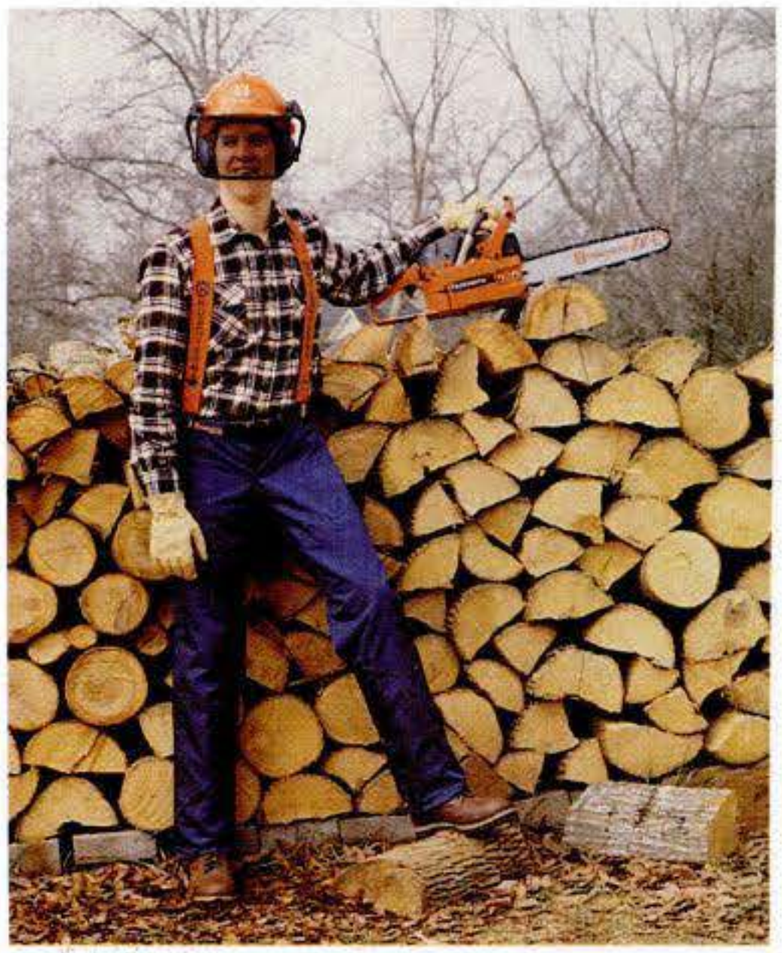
Storing Gasoline-Powered Outdoor Tools Properly Pays Off

When you have finished using your outdoor power tools at the end of a season, make sure that you store them properly. Clean and dry each tool carefully before you put it away. But you need to do more than provide safe storage for your tools if they are to survive months of inactivity.

If you leave gasoline in the fuel system, it will cause varnish to form on the metal surfaces. This varnish will jam fuel lines and can keep the tool from starting when you're ready to use it again. On the other hand, if you take all of the fuel out of the tool, rust can form inside the tank, and seals on the carburetor will dry out.

The solution: Read the manufacturer's instructions for off-season care. Tools like those in use on our remodeled home come with specific instructions for storage care. Some will recommend an additive that will stabilize the fuel and prevent it from forming varnishes, while others will recommend starting and running the gas-powered tool for a short period, perhaps 15 minutes, every few weeks during storage. Whatever is recommended, these instructions are vital to both the performance and longevity of the tool.



In front of his winter wood supply, homeowner wears Husqvarna protective pants, suspenders, safety hat, face mask, hearing protector.

Powerful New Chain Saw for Homeowners Is Easy on Users.

If you ask a homeowner what he wants in a chain saw, he'll usually mention a reliable saw that can handle frequent use and that will be easy on the user. Over the past few years, homeowners who need a durable chainsaw with those characteristics have made Husqvarna Model 50 a best seller in its class.

One of the advantages that users have particularly appreciated is the super-tough engine that bites hard even at low RPM. The effective cooling system enables the Husqvarna Model 50 to work well in even the hottest weather.

Another feature is the light, smooth saw body with handles built to divide the center of gravity evenly between the hands. With this design, the user can take a long shift with the Husqvarna without tiring.

For years one of Husqvarna's most popular saws, the Husqvarna Model 50 has recently been improved. It will still be called the Husqvarna Model 50, but will feature a 3.1 cubic-inch cylinder capacity (51cc) with a maximum no-load engine speed of 12,500 RPM. Recommended bar length is 15" to 20". A number of safety features, such as a manual and inertia-activated chain brake, front and rear hand guards, and efficient anti-vibration and noise reduction systems are standard. The new Husky Model 50 has been getting quite a workout at our remodeled home and has performed even beyond expectations. If you're thinking about a chain saw, think of Husqvarna Forest and Garden. Call your Husqvarna dealer today.

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Stapling, Tacking, Fastening, Hammering, Riveting or Gluing, We Needed a Fastener for It.

In our remodeled home, Arrow® Fasteners and Fastening Tools were put to extensive use by the contractor's workmen, and precision-made products by Arrow will later be helpful in many ways to the homeowning family.

The workmen became particularly attached to the Arrow No. HT-50A Heavy Duty Hammer Tacker, which was used for tacking insulation batts, as photographed. It is lightweight, with a balanced design that permits hours of stapling without strain. Roofers used Arrow No. HT-65 Extra Heavy Duty Hammer Tackers, which drive heavier, longer staples with wide crowns, to apply Owens-Corning Fiberglas shingles.

Another favorite of the crew, the versatile No. T-50 Heavy Duty Staple Gun Tacker is also used extensively by do-it-yourselfers for many good reasons. It shoots a staple anywhere you would drive a nail and does it faster, cheaper and better. The T-50 can be used for tacking insulation, ceiling tile, window screening, upholstering, carpet padding, fence wire, metal lath and hundreds of other light to heavy-duty tasks. It features all-steel construction, high carbon hardened steel working parts, easy double-leverage operation with patented jam-proof mechanism, chrome finish and a window that lets you see when it's time for a refill.

Other Arrow staple gun tackers are particularly suited to hundreds of fixing and fastening uses around the house. Home handymen and hobbyists will also be interested in the No. T-55, an excellent all-purpose tacker; homeowners will also appreciate the new T-27 Light Duty Household Staple Gun Tacker for screen repairing, light upholstery work, kitchen shelf trimming, closet lining, cornice covering and scores of other household tacking chores.

Arrow produces a complete assortment of quality fastening products, such as wiring tackers, Xpando staple gun attachments, tight-gripping Xpando fasteners and anchors, hot-melt glue guns, glue stix, removable weatherstripping, staples, rivet tools, rivets and other products that assure a good, clean job.

Arrow's No. HT-50A Heavy Duty Hammer Tacker drives staples automatically, as fast as the workman swings it, and is ideal for installing Owens-Corning Fiberglas insulation batts, as shown. Workman wears handy ProLite tool belt of tough Cordura Plus.

PERMITS AND APPROVALS

Make sure that local zoning rules permit new work and that you conform to minimum space requirements on sides and front. If you're using a contractor, he'll take care of it for you. Obtain a copy of zoning rules and building codes. If you need a variance, apply for one. Reasonable requests, particularly if supported by neighbors, will normally be granted. For most major remodeling, you'll need to file a construction plan and an application. Approval usually takes a week or so. If the work you're doing does not change or add to the basic structure, such as insulating the attic or redoing the kitchen, a permit is usually not required.

See the complete assortment of Arrow Fastening tools, staples, glue stix, fasteners and rivets, available at all leading Hardware, Home Center, and Discount Department Stores.

Arrow Fastener Company, Inc.
271 Mayhill Street, Saddle Brook, N.J. 07662
In Canada: Jardel Distributors, Inc. 6505 Metropolitan Blvd., East Montreal H1P 1X9 Quebec

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Don't Forget the Heat Wave of '88: Insulation Helps Year-Round

Last summer's record-setting heat wave and drought left many homeowners paying the price not only in discomfort, but also in high utility bills. One way to avoid "getting burned" in the future is by insulating your home; it can increase comfort and help save on energy costs year-round.

"Many people don't realize that insulation works in two ways," explains Frank Glover of Owens-Corning Fiberglas® Corporation, a leading manufacturer of energy-efficient building materials. "In the winter, it keeps the interior heat from escaping so the house stays warmer. In the summer, it reduces the need for continuous air conditioning by keeping out the summer heat. And that helps keep energy costs down."

Simple, Inexpensive

"Installing insulation in the home is a simple and inexpensive do-it-yourself project," Mr. Glover says. "Insulating a typical 1000-square-foot attic with 8-inch R-25 Attic Blanket®, for example, will cost around $300 to $350."

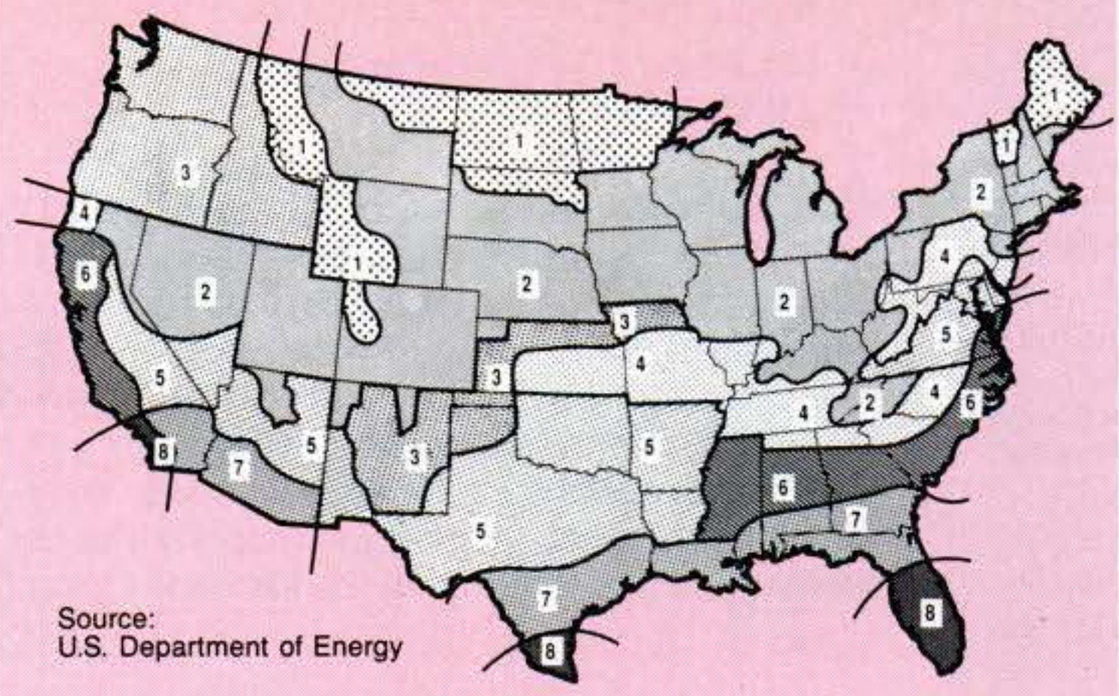
"The only tools needed are a sharp knife, a straight-edge, a measuring tape, a pair of work gloves, a mask, a long-sleeved shirt and safety glasses."

If the home has no insulation, the best place to start is the attic, followed by floors over unconditioned spaces.

Fiber glass batts, the most common do-it-yourself insulation, can be easily rolled out to blanket the desired areas. Most utilities will perform a low-cost energy audit (usually under $15) that points out areas where insulation needs upgrading.

As for the proper R-value (or insulating effectiveness) the Department of Energy has recently upgraded its minimum R-value insulation recommendations. Refer to the map and chart above to determine the insulation R-value recommended for your zone and your home's fuel.

NEW INSULATION RECOMMENDATIONS FOR YOUR AREA



RECOMMENDED INSULATION R-VALUES

	Ceilings Below Ventilated Attics		Floors Over Unheated Crawlspaces, Basements	B Exterior Walls (Wood Frame)	C Crawl space Walls
Climate Zone	Electric Resistance	Gas or Oil	ALL FUEL TYPES		
1	49	49	19	11	19
2	49	38	19	11	19
3	38	38	19	11	19
4	38	38	19	11	19
5	38	30	19	11	19
6	38	30	19	11	19
7	30	30	(D)	11	19
8	30	19	(D)	11	11

(A) These recommendations are based on the assumption that no structural modifications are needed to accommodate added insulation.

(B) R-Value of full wall insulation, which is 3½ inches thick, will depend on material used. Range is R-11 to R-13. For new construction, R-19 is recommended for exterior walls. Jamming an R-19 in a 3½ inch cavity will not yield R-19.

(C) Insulate crawl space walls only if the crawl space is dry all year, the floor above is not insulated, and all ventilation to the crawl space is blocked. A vapor barrier (e.g. 4 or 6 mil polyethylene film) should be installed on the ground to reduce moisture migration into the crawl space.

(D) Thermal response of existing space for cooling benefits does not suggest additional insulation.

NOTE: For more information see: DOE Insulation Fact Sheet (DOE/CE-0180)
U.S. Department of Energy
Technical Information Center
P.O. Box 62, Oakridge, TN 37830

Fiber glass batts clearly show the R-value on the package. To determine how much insulation to buy, measure the area to be covered and multiply the length by the width. Be sure to make any necessary repairs to the area, such as fixing leaky roofs and damaged floors.

For attics without floors, simply lay the batts between the joists with the vapor barrier facing towards the warm-in-winter side.

If adding a second layer, place unfaced insulation perpendicular to the existing layer. In addition to faced insulation or a separate vapor barrier, proper ventilation is also essential to prevent condensation. Eave vents—openings under the eaves—combined with roof vents or gable vents are effective ways to create a positive movement of air out of the attic.

Be sure to leave eave vents uncovered so you do not block the air flow—important in preventing moisture buildup and in reducing the attic temperature. As a general rule, one square foot of free vent area should be provided for each 150 square feet of floor when no vapor barrier is used. One square foot of vent area per 300 square feet of attic floor area is recommended when a vapor barrier is used.

Other Steps

Other simple steps you can take to help reduce cooling costs include:

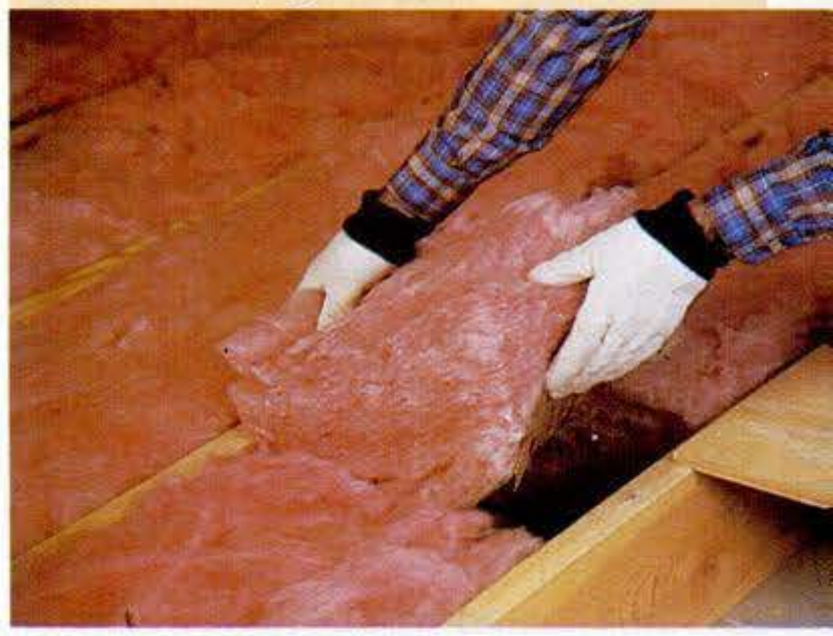
Air conditioners: Monthly upkeep will maintain efficiency and help cut energy costs. Clean the internal coils with a damp rag or soft brush and then vacuum. Foam filters should be washed or replaced at least once a month. For high efficiency, air conditioners should be serviced once a year: motors lubricated, coils cleaned and filters changed.

If possible, place the air conditioner unit in the north side of the home or in the shade, and try to keep the thermostat set at a comfortable 78 degrees. Utility findings show that each degree the thermostat is lowered represents a two or three percent increase in cooling costs.

Seal cracks: Caulk and weatherstrip doors and windows to reduce the infiltration of hot air. Weatherstripping (available as felt strips, foam rubber and flexible vinyl) is easy to install. Doors between an air conditioned and unconditioned space should be stripped on all sides, tops and bottoms. This includes entrance doors, attic doors and inside and outside basement doors, as well as window sashes.

Caulking is also a do-it-yourself job. Caulking guns and materials are inexpensive and available at hardware stores. To apply, move the tip of the gun along a crack as you squeeze out a thin bead of caulking compound. Cord-type caulking also can be used by pressing into place with fingers. Stuff deep cracks with mineral wool before caulking.

Installing fiber glass batt insulation in an unfinished attic is one of the most popular of all D-I-Y projects because it's easy to do and a real energy saver. Pictured below, a small piece of insulation is used where batts meet. Vapor barrier is facing down into the heated space below. Not shown: he's wearing a face mask and safety glasses.



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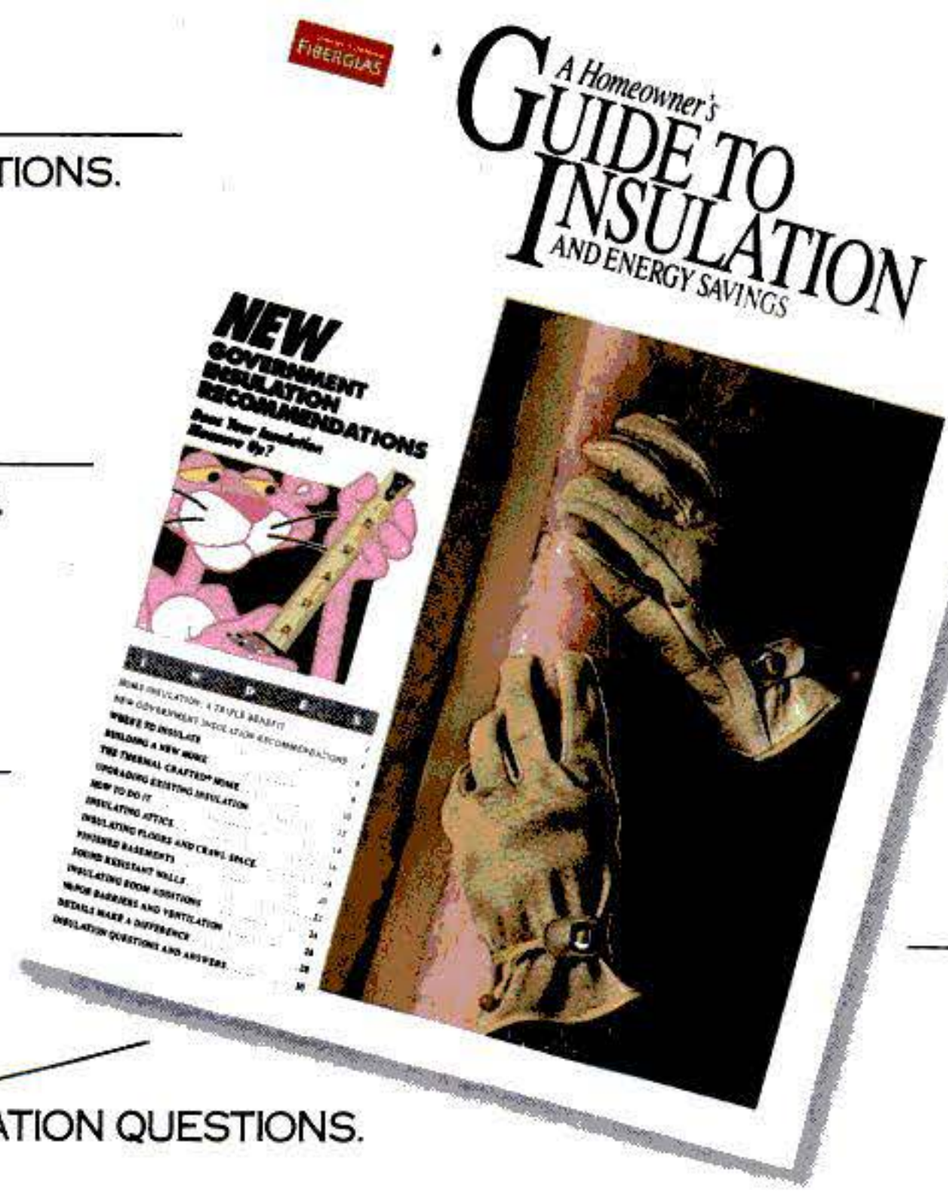
Free advice.

FIND OUT THE NEW DEPARTMENT OF ENERGY INSULATION RECOMMENDATIONS.

WHERE TO INSULATE FOR MAXIMUM ENERGY SAVINGS.

HOW TO UPGRADE EXISTING INSULATION.

ANSWERS TO THE MOST FREQUENTLY ASKED INSULATION QUESTIONS.



INSULATING A ROOM ADDITION, BASEMENT OR ATTIC CONVERSION.

INSULATION CONSIDERATIONS WHEN YOU'RE BUILDING A NEW HOME.

Owens-Corning just wrote the book on home insulation.

This comprehensive 32-page guide features the latest government insulation recommendations plus many other tips to help you save on your energy bills. So if you're planning to build a new home, add on to your house or just reinsulate, get a little free advice from the insulation experts. Owens-Corning Fiberglas. For a free copy, call 1-800-GET-PINK.

OWENS/CORNING FIBERGLAS

Mail to: Owens-Corning Fiberglas Corp., Attn: C.F.M. Meeks, Fiberglas Tower, Toledo, Ohio 43659.

Please send me a free copy of "A Homeowner's Guide to Insulation."

Name _____

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Workman delivers added summer comfort in the form of a new Lennox Power Saver® Two-Speed Air Conditioner. Tough Pickup is by Isuzu.

Year-Round Energy Savings.

The Lennox Power Saver® Two-Speed Air Conditioner uses only half the energy that a conventional single-speed unit would use. The secret of its operating efficiency is a two-speed compressor that shifts into high speed only 10 percent of the time and runs at low speed 90 percent of the time.

Power Saver is at its quiet best when you appreciate it most, in the morning and at night when it generally runs at low speed. Sound ratings are among the best in ARI listings for residential air conditioners. Standard features that reduce sound for extra quiet operation include a separate, insulated compressor compartment within the deluxe cabinet. A large condenser coil also reduces operating sound while adding to efficiency. The Power Saver carries a 10-year compressor warranty.

Ask your local utility company for the average cooling operating hours in your area. Then use the chart below to figure the comparative operating costs of the Lennox Power Saver versus an older model, plus the annual and five-year savings you can gain.

Average Annual and Cumulative Cooling Savings

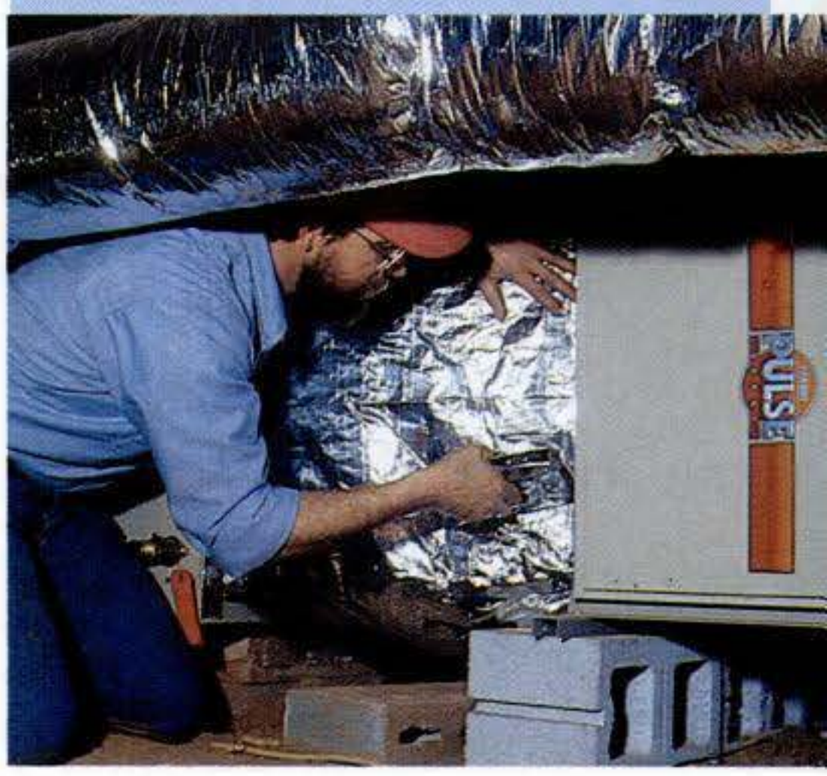
Average Cooling Operating Hours	500	1000	1500	2000	2500	3000
Annual Operating Cost* @ (15.0 SEER)	$ 93	$ 187	$ 280	$ 374	$ 467	$ 561
Annual Operating Cost @ (7.0 SEER)	$200	$ 401	$ 601	$ 801	$1002	$1202
Annual Savings With Lennox Power Saver*	$107	$ 214	$ 321	$ 427	$ 535	$ 641
Cumulative Savings Over 5 Years with Power Saver**	$590	$1181	$1771	$2361	$2952	$3542

*Average Annual Operating Cost Data is based on national average of 7.79¢/Kwh electric rate.

**Average Cumulative Savings Over 5 Years is based on a 5% annual escalation in the national average electric rate.

New Lennox Pulse™ gas furnace will cut heat bills almost in half due to revolutionary heat exchanger design, which captures more heat from the fuel. It avoids the chlorine problem faced by furnaces using indoor air for combustion, which may cause self-destruction, as it uses only outdoor air. PVC vent and stainless steel heat exchanger are highly corrosion resistant. Direct Spark Ignition eliminates need for standing pilot. Automatic Gas Valve shut-off and Automatic Pressure shutdown assure safe operation. The result of over 12 years of research and homeowner experience, Lennox Pulse™ has a Limited Lifetime Warranty on heat exchanger and condensing coil.

Workman installs ductwork for the Lennox Pulse™ gas furnace in crawl space. Horizontal and vertical venting options makes the Pulse easy to fit into any floor plan.



Rewiring Old Houses Is Tough and Expensive

The electrical upgrade of our house was scheduled for the late afternoons and evenings so that the construction crew and the electricians wouldn't be in each other's way. The electricians on our project felt that the electrical system in our house had been in fairly good shape overall but was quite uneven in its quality. The original system was porcelain-knob two-strand, much of which had been replaced in a range of skilled to nonskilled repairs and upgrades. As a result of expanded needs, it was agreed that every inch of wiring should be replaced. (New county and state laws also contributed to that decision.)

The old service included both 120 and 200 amp lines with ten 20 amp, three 30 amp and one 50 amp circuits. In the prepurchase inspection, the house inspector noted that one 20 amp breaker was protecting two circuits and recommended that another 20 amp should be installed. He also reported that the 50 amp breaker was protecting a number 10 wire and should be changed to a 30 amp. Our new and enlarged service has three 220 volt, eighteen 20 amp and three 60 amp circuits, with room for six more breakers. This new service has also been upgraded through the addition of a disconnect on the outside, providing protection from the meter to the inside panel, a new requirement in Morgan County. New no-fault breakers in the kitchen and bathrooms are also required by Georgia law.

The electrical foreman, who said that many electricians will not even do remodeling work, estimated that a new house with comparable electrical needs could be finished in less than half the time (270 versus 112 hours). He also suggested that remodeling homeowners hire an electrician on a per hour rather than a bid basis because older homes are unpredictable and bids will tend to be higher in anticipation of the worst possible cost problems. Perhaps his advice, coupled with a very basic cost-range understanding, is the best approach, with a maximum or ceiling cap in the contract. Fixtures can be bought through an electrician at costs that are very competitive with retail purchase; our electrician suggested that the owner should pick the fixtures to ensure visual acceptance, because tastes can vary so widely.

Tip: When inspecting a house, watch for connections in which the wires themselves have been twisted together before the connection caps are twisted on. Such a connection is a sure sign of an experienced electrician.

A New Water Supply for Growing Needs

Our prepurchase house inspection report was well worth the $125 it cost because it enabled us to get an early look at expensive repairs such as the roof, electrical and plumbing systems. Pursuing the new plans, Madison plumber Dale Knight has kept the house's water meter, but

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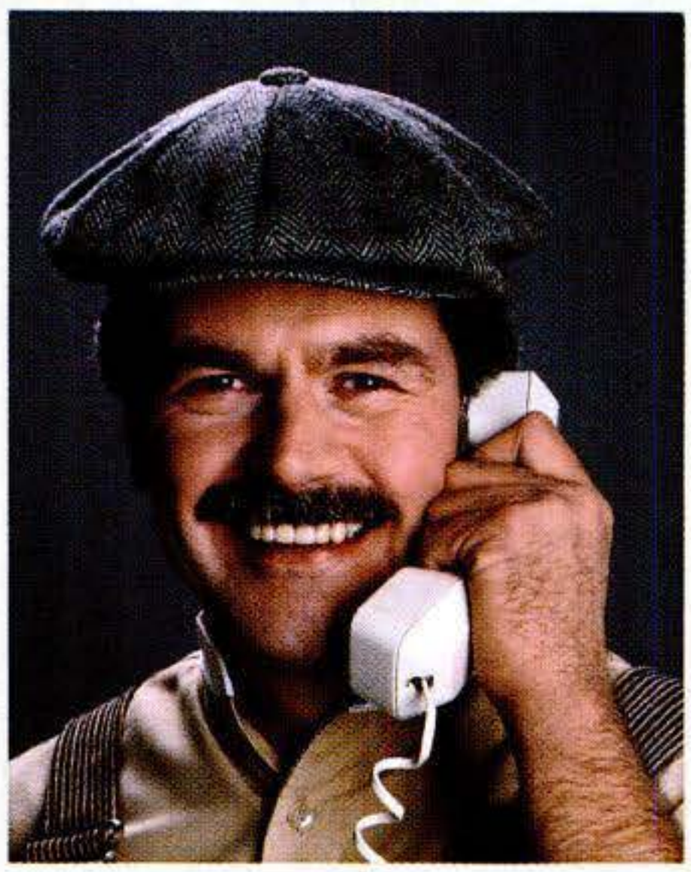
Last year, you probably paid too much to keep your home comfortable. But this summer you don't have to! Just call Dave Lennox on the 800 number below. Find out how Lennox high-efficiency heat pumps and air conditioning systems can save you money year after year. And let Dave connect you direct to a local independent Lennox dealer for information on his cooling specials and a no obligation estimate. Then you'll say, "Attaboy, Dave!"



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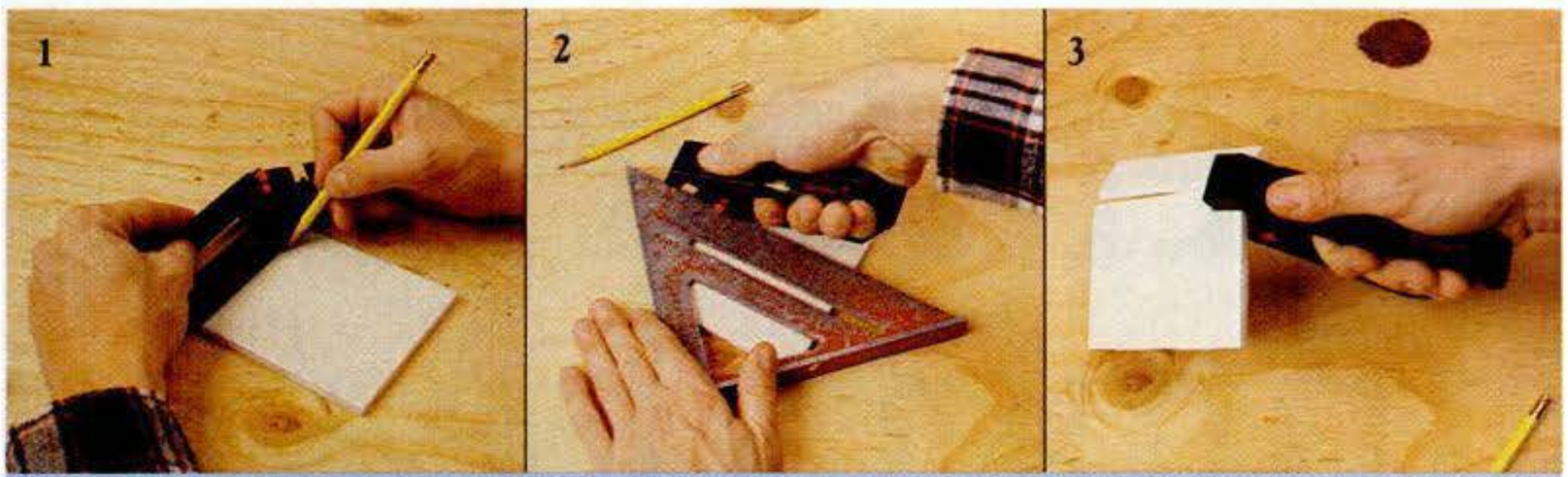


Red Devil® MasterCutter® directions: 1. Use scale on handle to measure and mark lines. 2. Be sure blade is fully engaged, then score with firm, even pressure until glaze surface is penetrated. 3. Open snapper jaw, place tile far back in jaws with glazed side up, line up score with center of top of tool, grip back of handle and squeeze. Practice a few times. Retract sharp blades when not in use. Safety goggles recommended.

Here's One Tile Tool That Scores, Snaps, Cuts and More.

It's hard to believe that any one tool can be as versatile as the new Red Devil® MasterCutter® Multi-Purpose Tile Tool. This tool scores, snaps, cuts tile, removes grout and also features a measuring rule, sanding paper for rough edges and a level indicator.

The Red Devil MasterCutter is manufactured from high impact plastic for maximum strength. It's also more comfortable than conventional tile cutters. A quality carbide scoring tip, the strongest available, scores, snaps and cuts wall tiles up to 6" x 6" and up to ¼" thick.

You save lots of time on your tiling project by using just one tool to complete the entire job. Also, you can save money by not having to purchase additional tools.

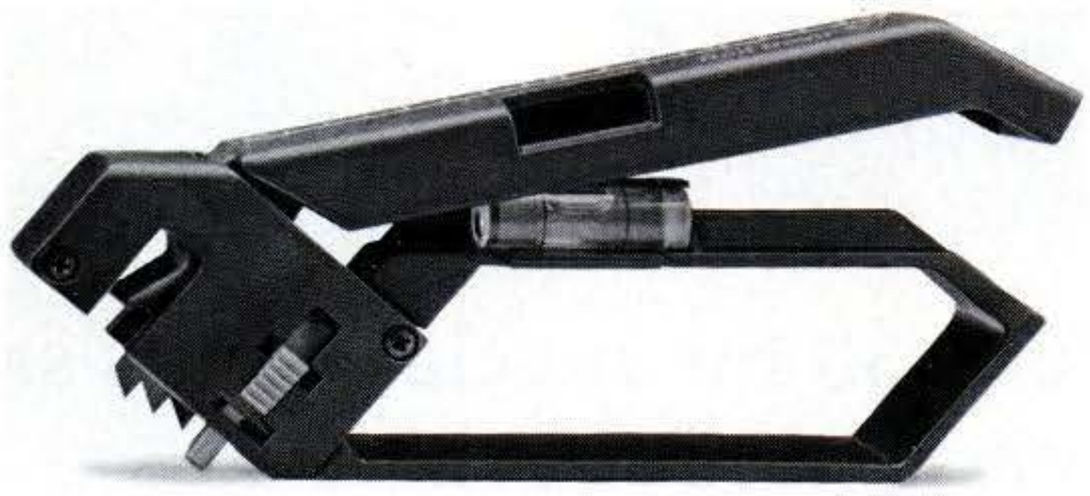
You can install ceramic wall tiles yourself, accurately and easily, with this multipurpose tile tool. Simply clean the surface and prepare according to the manufacturer's specifications.

Detailed, clear instructions for using the MasterCutter are printed on the package. Review them before you start to work. The Tile Cutter and Grout Remover are extremely sharp and must be handled carefully. Blades should be retracted when not in use, and all retractable blade mechanisms should be oiled for maximum tool life. Safety goggles are recommended when cutting tiles. You'll need a straight-edge ruler, crayon, cheese cloth or wiping rag, plus Red Devil Adhesive Spreader, Notched Trowel for tile and a Red Devil Tile Nipper for shape and contour cuts.

In addition to the handy six-in-one MasterCutter, Red Devil makes ceramic tile nippers, tile cutters, heavy-duty professional cutters and other durable high-performing products.

The Red Devil line contains over 400 different kinds of hand tools and chemical products for home maintenance and improvement.

The Six Tools You'll Need For Your Next Tile Project.



Why buy six tools for one job when one tool does six jobs?

The MasterCutter® six-in-one tile tool measures, cuts, snaps, sands, and levels tiles. Even removes old grout. And it fits in your pocket.

So take your next ceramic tile project in hand. Look for "MasterCutter" at your hardware or home center store.

Red Devil®

© 1989 Red Devil Inc.

from there on has replaced every inch of plumbing. (The plumber said our expanded needs were not unusual, except for the new Hot Spring Spa, which will be built into the rear deck.)

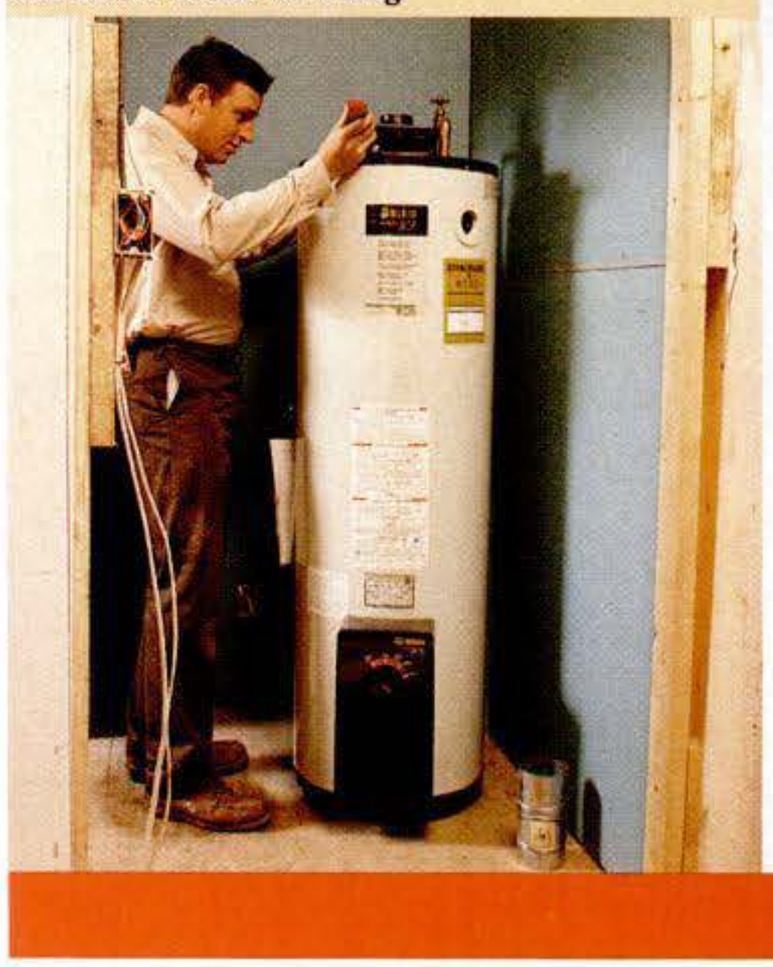
Dale has replumbed using copper for the supply line and PVC for the waste system. Copper, he feels, gives the house better water pressure and flow, and reduces annoying "air hammer" noises. Dale used lead-free solder throughout the supply system, as required by the state. PVC's smooth joints and interior surfaces help reduce sewage buildup in the waste system.

When finished, Dale will have logged in nearly 90 hours. Still to be done is a new sewage line to the street which will be laid immediately before the new concrete driveway is poured. Dale's father, also a plumber, will collaborate on that project.

Dale spends about 25 percent of his time on remodeling projects. He feels that for a project like ours, you should definitely look for a plumber with remodeling experience because of all the special problems posed by older homes. He also recommends that you buy your plumbingware through your plumber to save money and to guarantee satisfaction. As a buyer of thousands of dollars of material every month, he knows that he will get a better response to product failure than an individual homeowner can—and he'll also save money for his customer, through his discounts.

Dale guarantees his work for one year. Some larger products, like the Reliance water heater he installed for us, carry a five-year warranty.

From the supply room off the kitchen, an energy-saving Reliance® gas water heater, Sta-Kleen® model 805, will provide over 41% more hot water and save on operating costs. It's totally self-cleaning and never needs draining.



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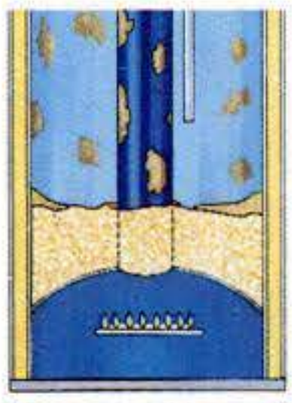
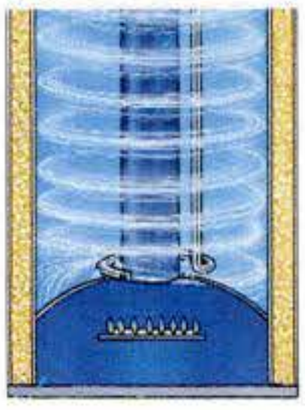
THIS IS THE STUFF THAT KILLS WATER HEATERS.

The Reliance Sta-Kleen® 805 gas water heater has the cure for killer sediment buildup.

Sediment inside the tank of an ordinary water heater can be deadly. It destroys efficiency increasing fuel use. And it promotes corrosion causing premature tank failure.

Sta-Kleen's patented self-cleaning design creates a vortex of turbulence inside the tank to prevent sediment accumulation. So it takes advantage of the economy of gas for years of trouble-free operation. Years of more hot water for less money.



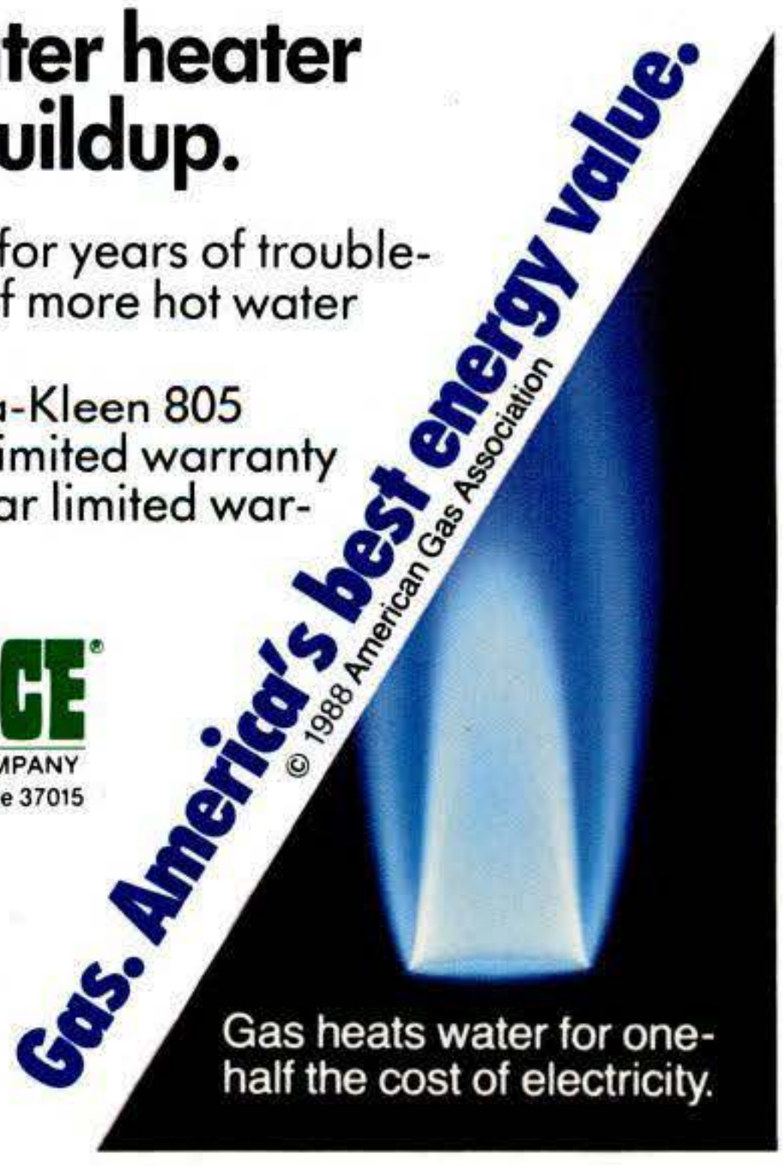


And every Reliance Sta-Kleen 805 comes with an 8-year limited warranty on the tank and a 5-year limited warranty on all parts.

130 Cumberland Street, Ashland City, Tennessee 37015

For the name of your nearest Reliance dealer, just call 1-800-365-4054.

Sta-Kleen 805 is manufactured under patent number 4, 505, 231.



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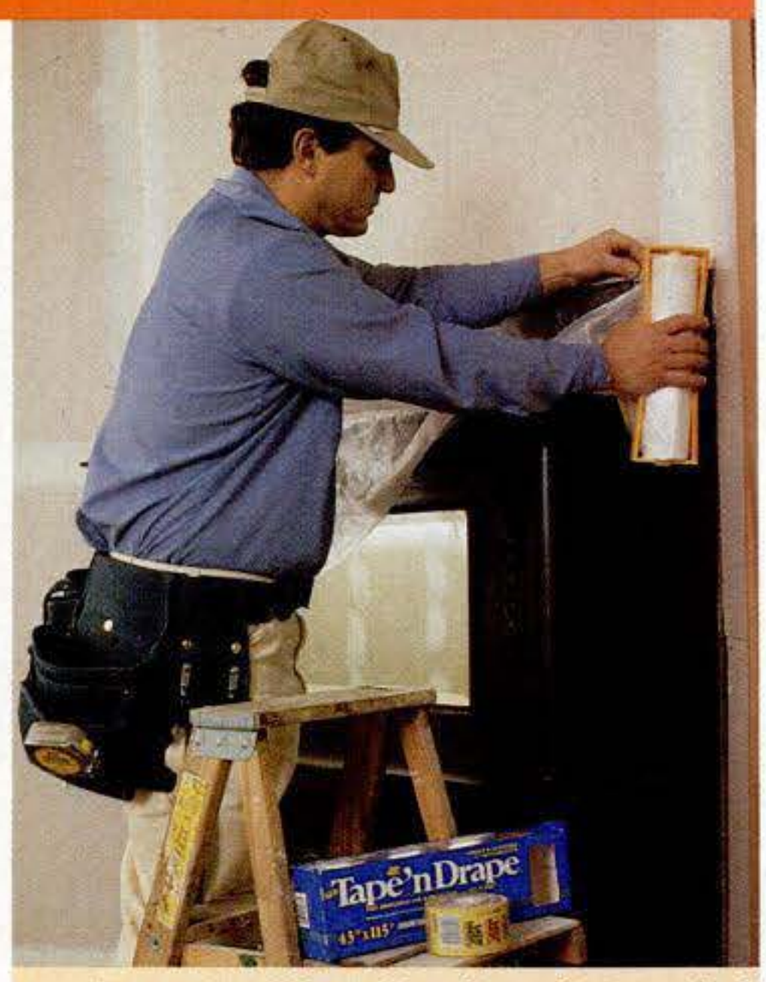
Timesaving for Professional Painters and Do-It Yourselfers.

Whether you're just a beginner, an experienced D-I-Yer or a professional painter, you constantly look for products that will help eliminate time-consuming cleanups and touchups. You want to control spills and splatters quickly, and you want to effectively mask off areas that are not to be painted.

Daubert Coated Products, Inc., a family of companies known for its innovations, has developed a line of timesaving products for all painters at all levels of skill. In painting our remodeled home, we used two of them quite extensively. The first was Daubert's Easy Mask® Painting Tape, a treated kraft paper with an acrylic-based, state-of-the-art adhesive. It provides a perfectly straight line and adheres firmly, yet removes easily, with no adhesive residue. This painting tape will mask floors, doors, windows and woodwork. It's available in convenient smaller sizes for D-I-Yers and in 400-foot rolls up to 12 inches in width for professional painters and decorators.

To protect larger areas against splattering, our painters used Daubert Tape 'n Drape®, which combines a high-quality straight-edge masking tape with a durable polyurethane drop cloth. It can be applied directly from a dispenser with its drop cloth folded; then the drape is unfolded when painting is to begin. Tape 'n Drape® is available in 115-foot rolls in a 4½" width (which unfolds to 21") or a 11½" width (which unfolds to 43").

Because time is precious, try these two helpful products from Daubert.



Daubert's Tape 'n Drape® is shown being applied from its dispenser to protect the mantel. Notice the Easy Mask® Painting Tape covering wood trim on the right.

Homeowners Becoming More Aware of Need for Reducing Radon Levels.

It is possible to bring down radon levels, if testing reveals that they're dangerously high, so the importance of early warnings is becoming more and more evident to American homeowners.

The federal government has now urged radon testing for almost every home in the country. After smoking, radon is the second leading cause of lung cancer, according to the United States Environmental Protection Agency and the Public Health Service, who attribute as many as 20,000 deaths per year to radon.

The two governmental agencies have issued a special joint warning as the result of a survey of seven states, which showed unhealthful radon levels in almost one-third of American homes, with a very high level belt ranging across North Dakota and Minnesota. The agencies recommend radon testing for all detached and row homes, apartments below the third floor and trailers. One high official said that he would not move into a house without knowing the radon level.

Your chance of developing lung cancer depends upon the concentration of radon gas and the length of time over which you are exposed, and this risk increases as both the level of radon and the length of exposure increase.

Now that you are aware of the dangers of high radon levels, how do you ascertain those levels? After all, you cannot see, smell or taste radon. Radon is a colorless, odorless, tasteless radioactive gas that comes from the natural breakdown of uranium. It can vary from one home to the next, can vary from one season to another, and can change with changes in barometric pressures. Special detection equipment and procedures are needed to protect your home against this radioactive gas.

The Survivor 2 has a microprocessor control which changes from a green all's well to a red light when the average radon level reaches four picocuries or more. Simple to operate, it has a Mode switch to display the long-term radon average of a period up to one year, or the average level of just the past 12 hours. Survivor 2 is a product of Threshold Technical Products, a charter member of the American Radon Association.

The Survivor 2 is installed in the crawl space under our remodeled home. The green light means alls well...

...a red light would mean that the radon level had reached four picocuries or more.

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Radon Monitoring

Survivor 2...short and long term protection for your home.

RADON is the radioactive decay product from uranium and radium.

- According to EPA estimates, radon causes between 5,000 and 20,000 lung-cancer deaths a year.
- Of the more than 15,000 homes tested by the EPA in the last two years, about one fifth had levels above 4 picocuries per liter.
- The EPA estimates unsafe levels of radon gas are in as many as 8 million homes in the United States.

With statistics like these, don't you want to protect your home from the dangers of radon gas?

Radon is odorless and colorless. It varies from season to season. It varies from neighborhood to neighborhood. It can even vary from your home to the home next door.

Why Continuous Monitoring?

It is estimated that the average radon level changes as much as 60% from season to season, while a simple change in the barometric pressure can change the level of concentration to at least five times the average level.

Now you can have CONTINUOUS monitoring of your environment for day to day changes in radon levels. SURVIVOR 2 will give you a continuous instant LCD readout of the level of radon in the last 12 hour period, or the last 365 days. Long term monitoring of your environment with SURVIVOR 2 will give you the average level of radon. The typical charcoal canister will only give the highs and lows from a one or two week period.

Simple to Operate

SURVIVOR 2, with its microprocessor controlled features, is simple to operate. In the 12 hour mode, a bi-color LED gives you a green light if the average radon level is below four picocuries per liter (which is the level recommended by the EPA), or it automatically changes to red when the level is equal to or exceeds that EPA recommended level of four picocuries. By using the MODE switch, SURVIVOR 2 will display the average level of radon in the last 12 hours, or it will display the average level for the last year.

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Satisfaction Guaranteed

Try some peace of mind at no risk. If you are not completely satisfied, return it within 30 days for a complete refund. Of course, SURVIVOR 2 is backed by a one year limited warranty on both parts and labor.

How to Order

By Phone: Call us toll free. A member of our sales staff will be glad to answer any questions and take your order. (Please have your VISA OR MASTERCARD available when you call.)

Call Toll Free 800-458-4931

By Mail: Send your name and complete address, daytime phone number, and how many SURVIVOR 2s you wish to order. Please enclose a check, money order, or card number and expiration date from your VISA or MASTERCARD.

SURVIVOR 2 $335.00
(Effective April 15, 1989)

(Ohio residents add 5½% sales tax)

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WILSONART®
BRAND DECORATIVE LAMINATE

Bringing new solutions to the surface™

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The highly styled Wilsonart® ColorVantage® laminate collection has been designed so that countertops and breakfast bar coordinate with cabinet doors in this striking new kitchen. Tappan gas range, oven and refrigerator help make life nicer.

Today, the Most Beautiful Surfaces Can Also Be the Hardest Working.

The fact that the most hardworking surfaces in today's home are often its most beautiful is a real tribute to contemporary design and laminate technology. The makers of Wilsonart® Brand Decorative Laminate pride themselves on "Bringing new solutions to the surface™". Their laminates were chosen by Zoe Van der Cleveland, our architect, for extensive applications in the Madison house. Zoe, collaborating with Wilsonart and Diane Steel, a Certified Kitchen Designer, selected the ColorVantage® collection for cabinetry and counters in the kitchen and great room. The ColorVantage collection is a special group of highly styled laminates with a heavy European influence that is geared for today's Euro style cabinet schemes. The line has been designed to coordinate with itself—for example, a cabinet door selection with a countertop selection.

Greyline, a vertical design comprised of faint grey and white stripes, was the cabinet door choice. Ebony Star was used on the countertop. It is a black and white speckled design with a glossy pebbled texture called Touchstone.

The cabinet door edges tied these two laminates together through the use of black Canplast® edgebanding material. To add the final touch or coordination to the ColorVantage kitchen, Strothmann® handles were used on the cabinet doors and drawers, matched exactly to the Ebony Star countertops.

Our two new bathrooms and new powder room will all use Wilsonart ColorVantage laminates for surfacing cabinets, tub platforms and surrounds.

Craftwood™ laminates are a line of real wood veneers bonded to a laminate backer, making a laminate that has a face of real wood. This product will be used for both the bookcases and wall panels in the new study. The grain of Craftwood laminates is so consistent that even clear lacquer was one finishing consideration. However, wanting a light, airy feeling, the designer chose Olympic's light Pickle Stain for this sophisticated new room.

Because of the durability and ease of maintenance of Wilsonart laminates, the study, kitchen and bathrooms of the remodeled house will earn praise for many years.

D-I-Yers Can Choose From a Variety of Doors and Shutter Styles.

A high-quality door or shutter to fit almost any D-I-Y project is now available from Wing Industries, the nation's largest manufacturer of bifold doors. In addition to doors, Wing also produces movable louver, fixed louver and designer shutter sets, as well as two styles of cafe doors. All Wing products are made to exacting standards with careful attention to detail, including knife-cut smooth finishing for staining and painting, and dowel-and-glue construction, the superior method of fitting wood together.

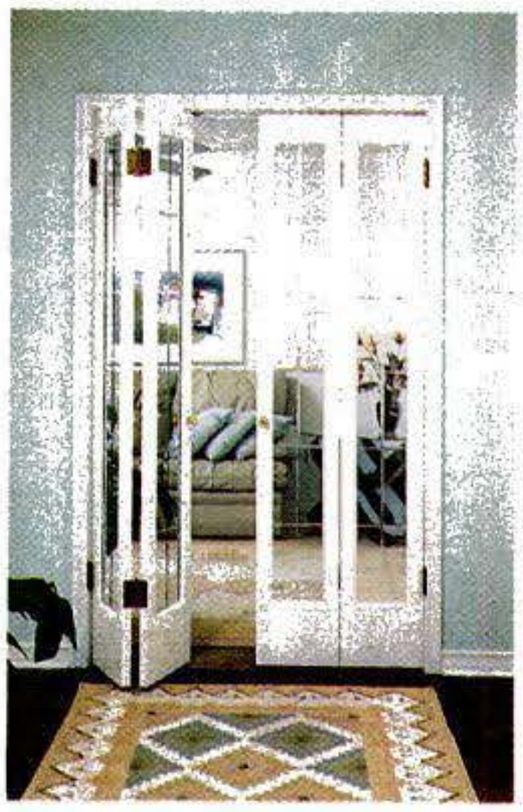
Doors come with all hardware, steel track and nylon pivots. Wing doors range from the traditional, colonial raised-panel styles to Victorian or contemporary glass designs, louver doors and mirror sliding panels and bifolds. Wing doors are made from Ponderosa pine, with glass tempered for strength and safety. Most are premasked for easy painting and staining, a very desirable timesaving feature, as we found out when we finished the new Wing doors in our remodeled home.

The Wing custom department can produce practically any design or any variation in their line, or can modify or create a product to fit any homeowner's requirements.

The most popular door models include La Door™, in a contemporary French style; Natchez, a Victorian, etched-glass design; six panel Colonial, a traditional, raised-panel door; and the new Florentine, an Italian-style floral, etched-glass bifold. Wing offers exceptional quality in a variety of beautiful styles.

View across the living room into new study is enhanced by beveled Wing bifold doors in elegant La Door style. Brushed-on Minwax® Polyshades® finish will give rich stain color and protection.

Fall in Love With Your Home All Over Again



When you add the warm, French country appeal of Wing's La Door to any room, you may fall in love with your home all over again.

La Door lets you dress up your home any way you want — with engraved glass or brass strip styling, in single, double and folding door styles. It's perfect as a passage door between rooms, like your living room and family room. And La Door comes in eight sizes, to fit almost any door opening.

If you'd like to go from drab to dramatic, contact your builder, remodeler or local home center.

WING INDUSTRIES

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Homeowners can now remove worn-out sash and hardware without having to replace existing window frames, using a convenient Marvin E-Z Tilt Pac. Workman shown removing old sash, leaving the original frame and trim, then replacing with new sash—all from the inside with no need to disturb siding, flat casing, interior walls or trim.

Great New Windows, Doors and Floors

Windows. We wanted to upgrade our windows for both appearances and energy savings, but we also wanted to retain the original look of the *Popular Science* house. Using the E-Z Tilt Pac from Marvin Windows, we were able to install new sash and hardware without disturbing the original frames or trim. The Tilt Pac provided us with two ponderosa pine sash, glass and jamb liners that would fit into the existing frames.

In addition to keeping the house's original look, Marvin Windows offered other important advantages. We replaced the original single putty-glazed glass with double-glazed insulating glass to lower energy costs. The heavy wood sash and the high-quality weatherstripping included in the Tilt Pacs ensured comfort and energy efficiency. Spring-balanced block-and-tackle hardware replaced the original double-hung system, providing a tight fit for sash yet still allowing easy tilt-in operation and removal for cleaning. Also, we saved considerable time and money by replacing only the sash and hardware instead of entire windows, and by not having to fit standard-sized windows into our 80-year-old openings.

Doors. Among the remodeling touches that are most noticed and draw most comment are the exterior door locksets. At our Madison home guests will be greeted in style by new exterior doors from Marvin. The elegant Barkley design handleset from Kwikset has been selected for the front door. For the interior, several different styles of Wing doors have been chosen, including the traditional six-panel Colonial and the La Door style bifold door for the new study. All doors will use Kwikset locksets and will be protected with Minwax® finishes.

Floors. After reviewing the flooring from front to back, we decided that the porch floor to be enclosed in the new study had to be rebuilt entirely because of rotting joists. The study and bedrooms will have new pine floors. Existing heart-of-pine floors in the living room and dining room were in satisfactory shape, and are being restored. Kitchen and hall flooring had sagged. We jacked up a beam and placed new supports there, then covered the kitchen floor with APA plywood sheathing, and now the kitchen and great room will have new pine floors. All wood floors await a variety of Minwax finishes, including a stenciled pattern in one of the children's rooms. New baths and powder room will have handsome tile floors.

Rich Wood Finishes Enhance Interiors.

When selecting wood finishing products, we went to Minwax®, the first name in wood finishing, for their products for finishing the wooden floors as well as for finishing the Wing Interior Doors specified in the design of the *Popular Science* remodeled home. Since it was founded 85 years ago, Minwax has maintained leadership in quality, consumer confidence and innovative development.

A labor-saving, cost-cutting new product from Minwax is one-step Polyshades®, a stain and polyurethane combination. Typically, wood finishing requires first a coat of stain, followed by a coat of polyurethane. Because Polyshades combines both of these products into one, you can cut down steps and cut finishing time in half. And, you're assured of a beautiful result that will last for years.

Minwax firmly established success in the wood finishing field over six decades ago with the introduction of Wood Finish, the most reliable wood-enhancing stain available—then and now.

Over the years, the Wood Finish color range has changed and expanded in response to decorating trends. Today, Minwax Wood Finish offers a timely range of 15 wood-tone colors and is America's number one wood stain by a margin of four to one over its closest competitor.

Topcoats. To provide the ultimate desired look and performance in wood finishing, Minwax offers a selection of quality topcoats with different degrees of hardness, protection and sheen.

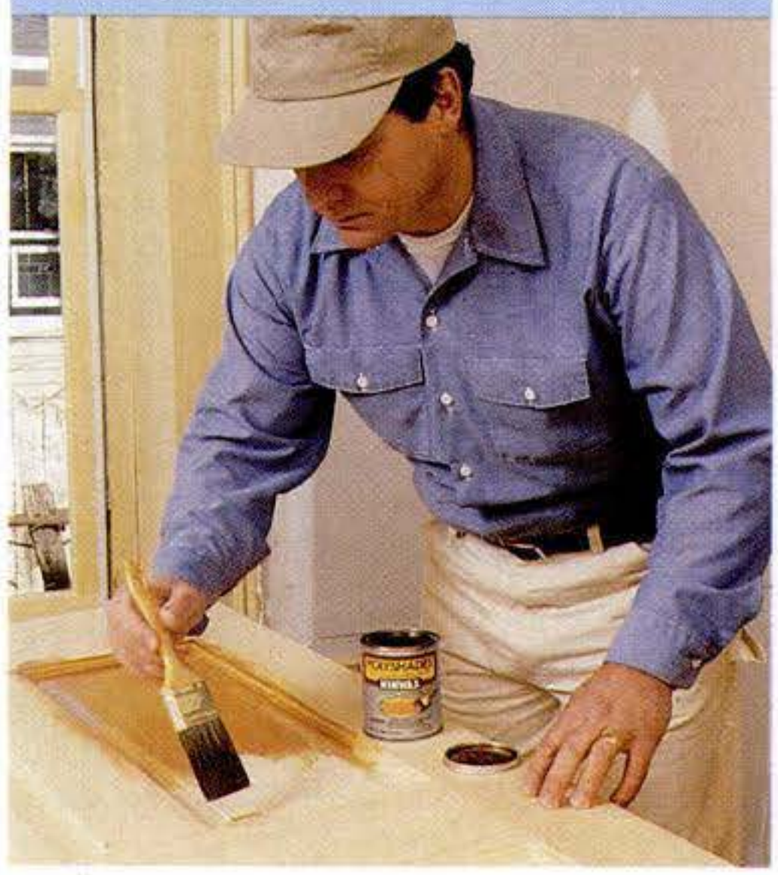
- **Fast-drying Polyurethane,** a long-lasting, scratch resistant, durable finish, ideal for floors, woodwork and furniture; available in clear gloss, semi-gloss and satin, as well as in aerosol form for easy application in hard-to-reach areas.
- **Helmsman® Spar Urethane,** an extra-tough, water-resistant finish for wet surfaces such as bar tops. For exterior use, ultraviolet absorbers help prevent yellowing and sun damage.
- **Antique Oil Finish,** a heat and scratch-resistant finish provides a rich, hand-rubbed lustre to woodwork and fine furniture.
- **Tung Oil Finish,** ideal for raw and refinished wood, penetrates deep into wood to restore richness and moisture, plus give a rich hand-rubbed lustre.
- **Paste Finishing Wax,** a truly traditional topcoat, provides a soft, glowing lustre and is available in Regular and Special Type for darker wood such as walnut.

One-Step Finishes. Minwax, in response to growing consumer demand for convenience products, offers two one-step finishes that can cut finishing time in half. Instead of first applying a stain, and then a topcoat, these products combine both in one stroke.

- **Polyshades®,** an easy brush-on finish, combines rich stain color with the tough protection of polyurethane in one application. In six wood tone colors, satin and gloss, it's ideal for finishing trim, paneling or molding.
- **WoodSheen®,** a wipe-on one-step product, combines penetrating stain with a protective Danish oil finish to provide a hand-rubbed look. Available in six colors plus Natural, it comes in a convenient squeeze bottle, and it dries in just two hours.

In addition to the wide range of interior and exterior wood finishes, Minwax offers related products which are designed to help the do-it-yourselfer achieve professional results.

The workman is shown with a Wing Interior Door, applying Minwax® Polyshades in Honey Pine, one of six wood-tone colors available in satin or gloss.



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Minwax opens more doors to your imagination.

Whatever wood finishing project your mind can conceive, Minwax can achieve. And in less time than you can imagine. Because Minwax has a full line of stains. Durable topcoats. One-step finishes. Fast-drying finishes. Brush-ons. Wipe-ons. Even wood repair products... Minwax has them all.

That's why Minwax is the only name you should look for, when you're working with wood.

For additional suggestions and projects, send for our FREE brochure, *Tips on Wood Finishing*. Write: Minwax, Dept. PS 049 P.O. Box 426, Little Falls, NJ 07424.

MINWAX®

Minwax products used above. Door #1: Golden Oak *Wood Finish* frame & panels. Early American *Wood Finish* bevelling. *Polyurethane* topcoat. #2: Natural *Wood Finish* Frame & Panels. Rosewood *WoodSheen* bevelling and stenciling. *Polyurethane* topcoat. #3: Honey Pine *Polyshades* frame. Olde Maple *Polyshades* panels. Royal Walnut *Polyshades* bevelling. #4: Dark Walnut *Wood Finish* frame. Provincial *Wood Finish* panels. Golden Oak *Wood Finish* bevelling. *Polyurethane* topcoat. #5: Antique Walnut *Polyshades* frame. Pecan *Polyshades* panels and bevelling. #6: Provincial *Wood Finish*, *Polyurethane* topcoat. #7: Natural *WoodSheen* frame. Windsor Oak *WoodSheen* panels. Colonial Walnut *WoodSheen* bevelling. #8: Special Walnut *Wood Finish*.

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Interior Painting Pointers

The Glidden Company was selected to supply interior paint for our project because of their nationwide reputation for quality, helpfulness and service to do-it-yourselfers, as well as professional painters.

Getting Ready to Paint. The ideal painting time is when room temperature is 70 to 72 degrees F. with windows and doors open for ventilation. Remove drapes, curtains, pictures, lamps and any furniture you can move. Cover heavy or too-bulky furniture with inexpensive plastic drop cloths. Use several layers of newspapers to cover floors or anywhere else paint may be splattered.

Preparing the Surface. Repair cracks or other flaws in the plaster or wallboard. If the wall is plaster, rake out all loose material with a sharp tool such as a nail or screwdriver. Using a flexible-bladed putty knife, work a good quality spackling compound such as Spred Patch® well into the area. For deep voids, allow the first application to dry, then fill the shrunken area and build a slight mound above the surface. Avoid grooving by using a putty knife blade wider than the void, let dry thoroughly and sand smooth.

Well in advance of painting, remove all sanding dust with a dampened cloth. If you have used any sort of mechanical sander, it's a good idea to vacuum the entire room, especially if you have removed wallpaper. After the room is clean, spot-prime each patch or repaired area.

Getting Started. If walls and ceilings need washing, wash the ceiling first—thoroughly, perhaps twice. Then wash the walls from the baseboard up to prevent wall-washing streaks on the lower areas.

Paint will not adhere to detergent or dirt residue, so rinse the wall clean, regardless of the direction on the detergent container. Allow complete drying. Let light fixtures hang freely by removing collars. Use cloths for extra protection over fixtures, especially the ones that are difficult to clean. Paint ceilings first. Remove all wall switch and outlet plates, even if they are to be the same color as the wall.

For "cutting in" or working one painted surface up to an edge that meets another area of a different color or finish, rollers alone are not adequate. Use a 1½" or 2" brush, or an edging tool at the ceiling line. The ceiling finish may pull away when masking tape is removed.

If you're painting directly from the can, pound nail holes around the rim so that excess paint can drip back into the can. Fill roller trays no deeper than the lower surface used to roll out the paint load.

Previously Painted Walls. Use a surface cleaning solvent on previously painted glossy or greasy areas. Before you start to paint, read all label instructions. Light surface sanding also cleans, but you must dust carefully afterwards. Light sanding also helps smooth out dust specks and other minor imperfections. Use steel wool on curved surfaces to avoid breaking through old paint film.

The Actual Painting. Do whatever cutting in you can reach easily within the first area, then area by area as you proceed. For precise cutting in around woodwork, use a well-tapered trim brush. If you have a great amount of straight-line cutting in to do, edging tools are great time-savers.

Don't load the brush too heavily. Hold it close to the heel for accuracy. Use masking tape, described in the Daubert Easy Mask® article, over adjacent areas to save time. Remove the masking tape immediately after trimming to avoid a ragged paint-film edge, especially if you're using fast-drying paint.

The most frequently used and speediest method of doing wall areas is rolling. Fill the deep end of the tray as far as the embossed slanted area. Use this area to even out the roller's paint load. Carry as much paint as possible without dripping.

Rolling Technique. Roll each area about 2 square feet, using a capital "M" pattern for unloading your roller, then filling in with parallel strokes. Roll gently until most of the paint is unloaded on the surface. Rolling too fast can cause paint to splatter. Overlap each rolling stroke about 50 percent with the previous one. Make finishing strokes in one direction, not back and forth.

Brushing Techniques. Dip the brush about half the bristle length into the container. Slap the bristles gently against the side of the can. Apply to the wall with crescent-shaped strokes in a small square area. Then finish-stroke all the same direction. Always finish-stroke *into* the previously painted area, not out to the unpainted area.

Ceilings. Rollers with extension handles can relieve the tedious work of brushing on ceilings. They eliminate moving stepladders and reduce the hazards of spilling and falling.

Cut in along the wall and ceiling line with brush or edger, or roll to the junction

Per prior agreement with the contractor, homeowner is painting kitchen walls before installation of cabinets, counters and appliances. After this priming coat, he'll finish paint with durable, easy-to-clean Glidden Spred® Enamel-Latex Semi-Gloss. Daubert Mask 'n Tape protects window frame, while drop cloth and roller extension save time and energy.

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Glidden research invented the first latex paint back in 1948. SPRED SATIN,® unlike oil-based paints, went on easily, dried quickly, and cleaned up with just soap and water.

Because SPRED SATIN was so easy to use, it not only revolutionized painting, but also helped establish today's do-it-yourself boom.

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There are over 9,000 Glidden dealers, and each one of them is ready to keep America rolling.

Glidden Your paint should be this good.

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of wall and ceiling and do the cutting in when you paint the wall.

Pick the short dimension of the ceiling. Paint across one end, doing a wide enough strip to suit your reach. Then go back to the starting side of the room and work parallel to the first strip, repeating over the length of the room.

Walls. Do the cutting in as you proceed around windows, door casings, fireplaces, shelves, etc. With a brush, apply a strip of paint 2" to 4" wide around the cut-in areas and roll up to them when the wall is painted.

Helpful Tips.

- Paper, fabric or other absorbent drop cloths are most practical on floors.
- Mask baseboards before painting, or use a piece of galvanized metal or aluminum with a straight edge to protect carpet.
- For longer-lasting rolling covers, clean pad applicators and edging tools quickly when finished. Clean paint completely from moving parts of roller frames.
- Tape screws to the fixtures they go with, and identify each piece by its location with a felt-tip marker.
- Don't allow latex-base paints to freeze. Pick up the paint last and carry it in heated part of the car.
- Only use nylon brushes with latex paint. Natural bristle brushes absorb water, will go limp and cake up too quickly.
- If using several quarts or several gallons of tinted paint, intermix all of the paint in a metal or plastic bucket before starting, to ensure uniform color, or disguise variations by making can changes at architectural breaks.

A People Plan, From Porch to Porch

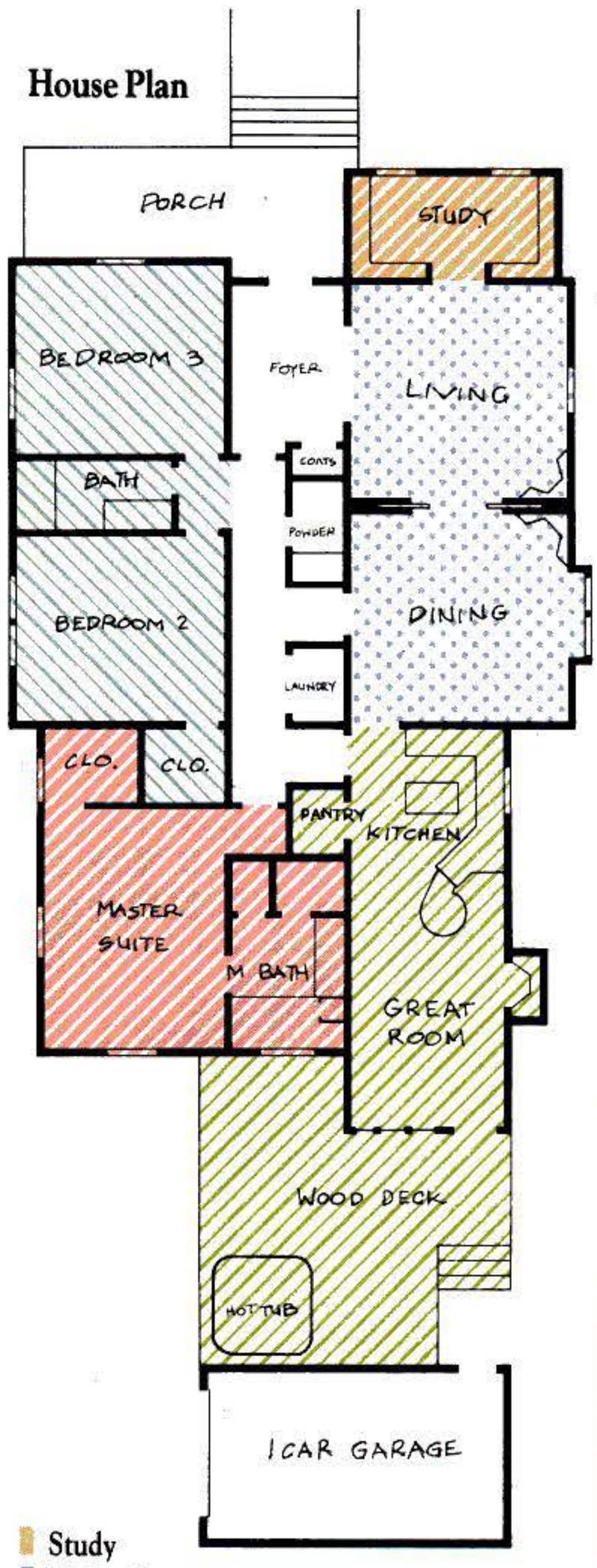
Our architect, hemmed in on the left and right by property ordinances, expanded the house by adding on to the front and back. In the front, nearly half of the porch will be enclosed for a gracious study. Main Street is much busier than it was around 1908, when our house was built, and trading half the porch for a new and elegant study appealed to the family.

Living room, dining room and two bedrooms for the children have been renovated, and the single bathroom has given way to two and a half. Energy-saving Lennox air conditioner and gas furnace plus Tappan appliances have been added.

In the back, the kitchen and great room flow into a new outside deck area. This new family-oriented space, with its Hot Spring Spa® by Watkins Manufacturing and charming breezeway, will become the leisure-time center of everyday life. A new master bedroom, with a luxurious bathroom featuring a spacious American Standard whirlpool bath, enhances lifestyle and ensures privacy for the parents.

In our June issue, you'll see most of these rooms finished and decorated. You'll also see how a new driveway, turnaround, garage-storeroom, garden, plants, irrigation, exterior music and more will be part of the relaxing landscape at our house on Main Street.

House Plan



- Study
- Living Room
- Dining Room
- Children's Bedrooms
- Master Bedroom
- Kitchen, Great Room and Deck with Spa

Watch for the Important Special Section in June

The final section in our three-part series will appear in the June issue of *Popular Science*. It will be very exciting because it shows the payoff: How all of the, planning, preparation, hard work and investment of time and money results in an intelligently renovated home that fits both the family and the neighborhood beautifully.

In addition to receiving more information and advice that you can use in your own home projects, and featured material from leading manufacturers, you'll see the completed home, lawn and garden.

You'll see how you could win the home— or $100,000 in cash or another great prize!

Entry forms will be found in the June issue of *Popular Science* or you can pick up a form at the participating retailers listed later in the magazine. There's nothing to write, nothing to buy and you could win the house or $100,000 in cash, or one of many other valuable prizes. All just for entering the big WIN THIS HOUSE SWEEPSTAKES!

See the completely remodeled home in June and make sure you enter the Sweepstakes. Some lucky person will win it (or $100,000). **That lucky person could be you!**

POPULAR SCIENCE HOME REMODELING GUIDE

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WHERE TO BUY LISTING

Look for the products featured in "The Home Remodeling Guide" at the stores listed below.

AMERICAN PLYWOOD ASSOCIATION

P.O. Box 11700
Tacoma, WA 98411

DAUBERT COATED PRODUCTS, EASY-MASK® AND TAPE 'N DRAPE

ALL STATES

All Ace Hardware Stores
All Gliddens Stores
All Servistar Hardware Stores
All Sherwin Williams Stores
All True Value Stores

CONNECTICUT

All Aubuchon Hardware Stores
All Grossman's Stores
All NHD Hardware Stores
Bridgeport • Paint Products
Norwalk • Brandman & Sons

DELAWARE

All MAB (MA Bruder) Stores
All Rickels Stores
Price's Corner • Buten Paints
Wilmington • B.F. Shinn
Wilmington • Mammele's

MAINE

All Aubuchon Hdwe. Stores
Bangor • Grossman's
Biddeford • Devoe Paints
Lewiston • Polar Paints
Rockland • E.C. Hart & Son

MARYLAND

All Duron Paints Stores
All Hechingers Stores
All MAB (MA Bruder) Stores
Baltimore • Budekes
Baltimore • Pittsburgh Paint
Gaithersburg • Barrons Gaithersburg
Millersville • Devoe Paints

MASSACHUSETTS

All Ashmont Supply Stores
All Aubuchon Hdwe. Stores
All Grossman's Stores
All NHD Hardware Stores
All Somerville Lumber Stores
All Town Paint Stores
Shrewsbury • Spag's Supply

NEW HAMPSHIRE

All Grossman's Stores
All NHD Hardware Stores
All Somerville Lumber Stores

NEW JERSEY

All Buten Paints Stores
All Channel Home Ctrs.
All Clovers Stores
All Duron Paints Stores
All Finnaren & Haley Stores
All MAB (MA Bruder) Stores
All Rickels Home Centers
All Siperstein Paints Stores
Belmar • Belmar Disc. Stores
Burlington • Burleigh's Pt.
Cherry Hill • Cherry Hill Atlas Pt.
Hackettstown • Paintpourri
Manasquan • Morton Paint Center
Maple Shade • Morris Maple & Son
Maplewood • Riccardi Bros.
Medford • Burleigh's Paint
Montclair • Red Star Paint
Nutley • Joe Riccardi
Princeton • Benningers Mtnside
Shrewsbury • Moran's Paint
Somerdale • Conroy's Corner
Somers Point • Millers Paint Ctr.
Succasunna • Delta Paint
Trenton • The Paint Barn

NEW YORK

All Channel Home Ctrs.
All Chase-Pitkins Stores
All Hills Dept. Stores
All Janovic Paint Stores
All Paint Fair Stores
All Pergaments Stores
All Rickels Stores
Binghamton • Binghamton Slag
Binghamton • Daniel's Paint
Brighton • Devoe Paints
Buffalo • American Wlpr.
Corning • Sevens Paint
Elmira • Elmira Paint
Ithaca • Ithaca Paint
Poughkeepsie • Sun Wallpaper

PENNSYLVANIA

All Brooks Paints Stores
All Busy Beavers Stores
All Buten Paints Stores
All Clasters Stores
All Clovers Stores
All Duron Paints Stores
All Finnaren & Haley Stores
All Rickels Stores
Brodheadsville • Corner on Paint
E. Greenville • Bauman Paint
Erie • Chas. Padden
Erie • Erie Paint
Feasterville • Bucks County Pt.
Latrobe • Action Home Ctr.
Pittsburgh • Masterwork Pt.
Pittsburgh • Sternberger Pt.
Pittsburgh • Wheeler's Pt.
Warren • Jensen Paint

RHODE ISLAND

All Ann & Hope Stores
All NHD Hardware Stores

VERMONT

All Aubuchon Hdwe. Stores
All Grossman's Stores

GENOVA RAINGO®

ALL STATES

All Aubuchon Dealers
All Builder Mart Stores
All Cotter True Value Stores
All Grossman's Stores
All HWI Stores
All Hechinger Stores
All Lloyd Home & Building Centers
All LMC Dealers
All Mr. Goodbuy Stores
All Pro Hardware Dealers
All Servistar Stores
All Somerville Lumber Stores
All Trustworthy Hardware Stores

GEORGIA BOOT®

CONNECTICUT

Berlin • Mickey Finn Stores
Branford • Palaias Dept. Store
Bridgeport • Jimmy's A & N Store
Bridgeport • M-Schnieder Inc.
Bristol • Irvings A & N Store
Bristol • Ray's A & N Store
Canaan • Bob's Clothing & Shoes
Danbury • Bojest, Inc.
Danbury • New England Uniform
Danielson • Keech's Dept. Store
East Hartford • Harbert, Inc.
Enfield • Bob's Stores
Fairfield • East Coast A & N Store
Farmington • J.C. Penney
Hamden • Bob's Stores
Henington • New England Safety Shoes Co.
Manchester • Bob's Stores
Manchester • Doug's A & N
Middletown • Bob's Stores
New Britain • Eblen's A & N Stores, Inc.
New Hartford • P.H. Roberge & Son
New Haven • Austin Philips
New London • Marcus/Jeans
New London • Pragues Shoes
New Milford • County A & N Store
New Milford • Save on Shoes
Norwich • Chelsea Outfitters
Norwich • Gordan Shoe Outlet
Norwich • Pragues Shoes
Old Saybrook • John & Kay Ent.
Rockville • Zahner's Shoe Store
Seymour • Country Stores
Stafford Springs • National True Value Hardware
Stamford • Cousins Clothing
Stratford • Liberty A & N Store
Stratford • Stratford Bootery
Waterbury • Amici Dept. Store
Waterford • J.C. Penney
Westport • Liberty A & N
Willimantic • American Waste & Metal

DELAWARE

Dover • Kohn's Mens Wear
Newark • The Generals A & N Inc.
Wilmington • Al's Play-Time, Inc.

DISTRICT OF COLUMBIA

Washington • Sunny's Surplus Stores

MAINE

Biddeford • Spellman Shoe
Brewer • Epsteins Inc.
Brewer • Mardens Shoes
Brewer • Miller's
Calais • Boston Shoe Store
Ellsworth • Willey's
Fairfield • Marden's Shoes
Kittery • Kittery Trading Post
Lewiston • Gary's Army & Navy
Lewiston • Louies Clothing
Lewiston • Mardens Shoes
North Windham • Sebago Trading Post
Oxford • Ray's Place
Portland • Maine Surplus Sales
Portland • Mardin's
Portland • Mortts Factory Outlet
Patten • McKenney's Clothing
Rockland • Tuttle Shoe Co.
Skowhegan • Griffins Cash N' Carry
Skowhegan • Lacasse Shoe Repair, Inc.
South China • Farrington Clothing & Shoes
Waterville • Levine's
Yarmouth • Howard's Leather

MARYLAND

Annapolis • Sunny's Surplus Stores
Augusta • Quality Shoe Store
Augusta • Top Kick Army-Navy
Baltimore • Hankin Bros.
Baltimore • J.C. Penney
Baltimore • Levy's Shoe Store
Baltimore • Shane Shoe Stores
Baltimore • Sunny's Surplus Stores
Belcamp • Belcamp Factory Outlet
Biddeford • Feinberg's Inc.
Caithersburg • Wolfson's Dept. Store
Crisfield • Wilson's Family Shoes
Cumberland • Super Shoe Stores
Easton • Fox's Family Store
Elkton • Peebles Dept. Store
Ellicott City • Sunny's Surplus Stores
Forest Hill • C-Mark
Frederick • Picway
Frostburg • The Connection
Glen Burnie • Sunny's Surplus Stores
Hagerstown • J.C. Penney
Hagerstown • Keystone Country Store
Hagerstown • Rosen's Dept. Store
Hagerstown • Super Shoe Stores
Huntingtown • Gardners
Leonardtown • Mickey's Shoes
North East • Cramer's Dept. Store
Towson • Sunny's Surplus Stores
Towson • Towson Bootery
Waldorf • Peebles Dept. Store
Waldorf • Waldorf Army-Navy
White Plains • Maryland Surplus & Outdoor

MASSACHUSETTS

Allston • Chains Bargain Store
Amesbury • Ben's Uniforms Inc.
Belmont • Dittos
Boston • Bay State Uniform Co. Inc.
Boston • Billy Vigor's
Boston • Mass Army Navy Store
Boston • Walker's Riding Apparel
Bradford • Bradford Shoe Store
Bridgewater • Gotshalks Inc.
Cambridge • Central War Surplus
Cambridge • David's Famous Name Shoes
Cambridge • Garment District
Chicopee • Sentry Uniform
Clinton • Mellos Army and Navy Store
Dennisport • Factory Shoe Mart, Inc.
Dorchester • McCarthy Inc.
Dudley • Jeans Warehouse
E. Brookfield • Brookfield Factory Outlet
Gardner • Dows Shoe Store
Gloucester • Nelson's
Holyoke • Filbek Uniform Co.
Holyoke • Oscar Bail Shoe Store
Hudson • Elbee Shoe Inc.
Hudson • Webster of Hudson
Hyannis • Jeannery
Ipswich • Hills of Ipswich
Lawrence • Kenner's Shoe Store
Lawrence • Phillips Shoes
Lowell • Factory Shoe Outlet
Lowell • Thorndike Factory Outlet
Lynn • Jerry's of Lynn, Inc.
Lynn • Penneyworths, Inc.
Malden • Jerry's
Malden • Malden Army Navy
Maynard • Maynard Outdoor Store
N. Reading • Abbott Factory Shoe Store
Natick • Natick Outdoor Store
New Bedford • Carters of Bedford
Norwood • Mortt's Factory Outlet
Orleans • M-C Army Navy Store
Peabody • Pennyworths
Randolph • Brodils Bootery
Readville • Company Store
Rockland • Holsteins
Salem • Jerry's Dept. Stores, Inc.
Salem • Mortt's
Saugus • Pennyworths
Shrewsbury • Mat Shoes
Shrewsbury • Spags Supply Co.
Somerville • Modern Shoe Store
Springfield • Lucky Foot Wear
Taunton • St. Pierre Shoes
Townsend • Evans on the Common
Wareham • Guerras Footwear
Williamsbury • Williamsburg Feed & Farm Supplies
Worcester • Capital Shoe Outlet

NEW HAMPSHIRE

Claremont • Harry's Shoe Barn
Colebrook • Hills Dept. Store
Derry • The Country Gentleman
Dover • Reds Shoe Barn
Franklin • Charley Shoes
Groveton • Dupuis Country Store
Hampton • Famous Boot Outlet
Keene • Miltners Shoes
Keene • Mortt's Shoes
Laconia • Beaulias Wear All
Manchester • Bee Bee Factory Store
Manchester • Mortts Factory Outlet
Meredith • Meredith Trading Post
Nashua • Alecs Shoes
Newport • Huberts Dept. Store
Pittsfield • Barneys Clothing
Plaistow • Reds Shoe Barn
Plymouth • Salibas
Raymond • Raymond Variety
Rochester • Miltners Shoes
Rye • Famous Boot Outlet

NEW JERSEY

Aberdeen • Dalbergs Wide Width Shoes
Atlantic City • Max Green & Son, Inc.
Bayonne • Monte Schinasi
Bayonne • Surplus A & N Inc.
Bergenfield • Fasano's Home of Good Shoes
Bergenfield • Sneaker King Corp. DBA
Berlin • Howard Shoe, Inc.
Bloomfield • Economy Self Service
Bound Brook • Efingers Sporting Goods
Brick Town • Casciones Shoes
Burlington • Kay Mft. (Gregory's)
Camden • Garden State Surplus
Carteret • Hammers Mens Store #2
Cedar Run • Green Sales & Rental, Inc.
Columbus • Jay & El Shoes
E. Brunswick • Charlotte Shoes
E. Brunswick • J.C. Penney Co.
Elizabeth • Jackson Sales, Inc.
Elizabeth • Mannings
Elmwood Park • Olympic Glove, Inc.
Farmingdale • Collingwood Park Shoes
Flemington • Flemington Dept. Store
Franklin • Weiners Step in Shoes, Inc.
Freehold • Miller Uniform Co. Inc.
Hackensack • Jules Prosnitz & Sons, Inc.
Hewitt • Greenwood Lake Sports
Hillside • Industrial Outfitters, Inc.
Hoboken • Goodmans Inc.
Irvington • Joe's A & N Store
Jersey City • Kings Son, Inc.
Kearny • Drover Bay Trading Post
Kearny • Wel-Fit Shoes, Inc.
Keyport • La Conte Work Shoes
Lakewood • The Sneaker & Shoe Den
Linden • Julien's Army & Navy, Inc.
Linden • Shoe Place
Lodi • Ira Gerstein
Madison • M & W Company, Inc.
Middlesex • Middlesex Army Navy Store
Middletown • Bob's Uniform Shop
Middletown • Eastmond Uniforms
Midland Park • Manor Shoes
Millville • Frank's Mens & Boys Store
Montclair • L. Walensky, Inc.
Morristown • The Work & Wear Store
Mount Ephraim • Rubys Shoes, Inc.
Mount Holly • Gregory's 2
New Brunswick • O K and H'Wang, Inc.
Newark • A Nossa Terra
Newark • Katzins
Newark • Universal Men's Store
Nutley • Plaza Bootery
Ocean City • Leons Mens Shop
Orange • Salzmans Dept. Store, Inc.
Pennsauken • I. Goldberg Mgmnt Corp.
Piscataway • Dollar Shoe Outlet
Plainfield • Strand Dept. Stores, Inc.
Pleasantville • Fazio Shoes
Pleasantville • The Hub
Pompton Lakes • Wechts, Inc.
Princeton • Princeton A & N Store
Rahway • Stromfield Shoes, Inc. DBA
Raritan • Glasers Dept. Store
Rosenhayn • Marx Weinstein Gen Store
Rutherford • Suburban Mens & Boys
Salem • Jacks Mens and Boys Stores
Secaucus • Marty's Shoes, Inc.
Short Hills • Bill's A & N Store
Somerset • John's Inc.
Somerville • Somerville Enterprise, Inc.
Somerville • The Hub
South Amboy • Bayshore Cycles Corp.
Totowa • Felsway Corp.
Trenton • Desanctis Shoe Shop
Trenton • T.J. Leeman, Inc.
Villas • Delaware Bay Trading Post
Vineland • Bernies A & N
Wall Township • Bills Work Clothing Store
Westwood • Nahm Shoe Store of Westwood, I
Wildwood • Silens
Williamstown • Ruby's Shoes
Woodbridge • J.C. Penney, Co.
Woodbury • Polskys Army & Navy Store
Woodcliff Lake • Central Military Surplus
Woodstown • Hart Shoes & Service Inc.

NEW YORK

Albany • Dan Adrondack
Amsterdam • Miller Mens & Boys
Astoria • Bar Ted Army Navy
Babylon • Lo-Man Outdoor Store
Batavia • Melton Shirt Factory
Batavia • Thomas & Dwyer
Bath • Harold's A & N Store
Bayshore • J.C. Penney Co.
Bayside • Bell Army Navy
Beacon • Schumans A & N
Binghamton • Harold's A & N Store
Brockport • Castle Clothing
Bronx • Arrow Army Navy
Bronx • Bucks Work Clothes
Bronx • Ditris General Mdse.
Bronx • Dr. Jays
Bronx • F & J Police Equip.
Bronx • Frank's Sport Shop
Bronx • H & R Hosiery
Bronx • H & Y Sportswear
Bronx • Harry's Army Navy
Bronx • Jay's Sporting Goods
Bronx • Kingsleys
Bronx • Varsity Mens Shop
Bronx • White Stone Eagle
Brooklyn • Capital Stores
Brooklyn • Carl & Sons
Brooklyn • Catos Army Navy
Brooklyn • Circle Work & Western
Brooklyn • Dr. Jays
Brooklyn • Fred Levy
Brooklyn • Henrys Variety
Brooklyn • JMD Square Stores
Brooklyn • Naomia Enterprises
Brooklyn • Outdoor Sales
Brooklyn • Phils Men's Shop
Brooklyn • S & A Shoes
Brooklyn • Sam's Work Clothes
Brooklyn • Simons Industrial Supply
Brooklyn • Sneaker City
Brooklyn • Sports and Shops
Brooklyn • Stevies Fashion Shoes
Brooklyn • The Trader
Brooklyn • Triangle Sporting Goods
Buffalo • Howard's Shoe Store
Buffalo • McKay's Work Clothing
Buffalo • Washington Surplus Ctr.
Canandaigua • Altier's Shoe Annex
Canandaigua • Harold's A & N Store
Centereach • Centereach Work & Play
Chittenango • Waldman's Dept. Store
Cobleskill • Wohl's Dept. Store
Commack • Craft Shoes

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WHERE TO BUY LISTING

Look for the products featured in "The Home Remodeling Guide" at the stores listed below.

Corning • Harold's A & N Store
Corona • Gordon's Army & Navy
Croglnan • E.M. Marilley & Co.
Dansville • Harold's A & N Store
Depew • Lancaster Depew Surplus
E. Hampton • The Cobbler Shop of E. Hampton
E. Northport • East Northport Army Navy
Elmira • Harold's A & N Store
Floral Park • D. Moss Shoes
Florida • Werners Dept. Store
Flushing • Galaxy Army Way
Flushing • Joes Army Navy
Franklin Sq. • Northshore Army Navy
Fulton • Seibeh's Shoe Store
Glen Cove • Bellocco Shoe
Greene • Miller Shoes
Greenville • The Westerner
Hauppauge • Charles Greenblatt
Harverstraw • Leo's Ivy Shop
Hempstead • Hempstead Outdoor Store
Hicksville • Coldman Bros.
Holbrook • Tally Shoes
Hornell • Harold's A & N Store
Horseheads • Harold's A & N Store
Hudson • Rudnicks
Hyde Park • Hyde Park A & N
Ilion • Wagner Shoes
Islip • Cousins Army Navy
Ithaca • Harold's A & N Store
Jackson Hts. • Brown's Bargain Store
Jamaica • B & H Lee Marketing
Jamaica • Berry's Shoes
Jamaica • Central Mens Shop
Jamaica • Mesk Police Equip.
Johnson City • Rasco Shoes
Lansing • Harold's A & N Store
Larchmont • Plaza Bootery
Levittown • Shoe Nuf
Lindenhurst • Bell Army Navy
Lockport • Lockport Surplus
Lowville • M. Coahn & Sons
Maine • Barnes Store
Maspeth • G & G Dept. Store
Massapequa • J.C. Penney Co.
Medina • Mark & Dale Apparel
Merrick • Robinhood Surplus
Middletown • H & G Webers
Middletown • Middletown A & N
New Hyde Park • Sandy's Sportswear
New York • 59th St. Men's Shop
New York • ABC Army Navy
New York • ABC Sporting Goods
New York • Angie Step Shoes
New York • Campton Army Navy
New York • Catch Ball Products
New York • Cedardale Army Navy
New York • Chelsea Army Navy
New York • Choi Sporting Goods
New York • Clarks
New York • Daves Army Navy
New York • Dr. Jays
New York • Fashion News
New York • Hildas Shoes
New York • Kaufman Surplus
New York • Leaders Mens Shop
New York • Magic Shoes
New York • Mash Army Navy
New York • Richards Sporting
New York • Sports Complex
New York • The Trader
New York • Village Army Navy
Niagara Falls • Howards Shoe Co.
Niagara Falls • Lasalle Shoe Store
Oceanside • Nemos Army Navy
Olean • Harold's A & N Store
Oneonta • Harold's A & N Store
Ozone Park • Bob's Sneaker Corner
Pine Bush • Sneaker to Boots
Port Henry • Sam Sagan & Co.
Port Washington • Bay Bootery
Potsdam • Cowens Country Store
Poughkeepsie • M & N Sales
Richfield Springs • Rick's Clothing & Footwear
Richmond Hill • K. Uniform
Richmond Hill • West Shoes
Riverhead • Bridge Army Navy
Rochester • Altier's Shoe Annex
Rochester • Harold's A & N Store
Rockville Center • A-1 Uniform
Rome • Herb Philipson's A & N
Saranac • Saranac Valley Feed
Sayville • Sayville Uniform
Schenectady • Andy's A & N
Schenectady • Bimor Govt. Surplus
Schenectady • Mohawk A & N
Schenectady • Rudniks
Seaford • Manno Uniform
Selden • Sierra Surplus
Seneca Falls • Ceo & Rutz Shoes
Stamford • Wohl's Dept. Store
Staten Island • J.C. Penney
Staten Island • Nathan's Work Clothes
Staten Island • Steckmans
Syracuse • Central Surplus
Syracuse • Sam Young Shoe Store
Tonawanda • Payne Shoes
Troy • Colonial A & N
Valley Stream • J.C. Penney Co.
Valley Stream • Rotondi
Vestal • Harold's A & N Store
Watertown • Apex A & N
West Haverstraw • Sneaker's Shoes Trading Post
Wolcott • Gallo Wolcott Outlet
Woodhaven • R & S Army Navy

PENNSYLVANIA

Allentown • Knapp Shoes
Allison Park • The Cobbler
Altoona • Super Shoes
Ashland • Charles Daley
Aspinwall • Otto's Shoe Store
Aston • Star Army & Navy, Inc.
Bangor • Army & Navy
Belle Vernon • Picway
Bellefonte • Ken's Boot Shop
Bellevue • Lisantis Shoe Service
Benton • Benton Sport Center
Boyertown • Howard Merkle
Brackenridge • Paul Dileo's Shoe Service
Bridgeville • Frank's Shoe Repair
Brodheadsville • Village Shoe Store
Broomal • Bill's Shoe Country
Butler • Workmens Supply Co.
Canton • T. Burk's Company
Carnegie • Hanna's Workingmans
Charlerio • Pagano Shoes
Clearfield • B & J Boot Shops
Connellsville • New Haven Expedition
Corry • J.B. Footwear
Curryville • Burgets Hardware
Denver • Weavers
Du Bois • J.B. Footwear
Edinboro • Malecs Clothing
Elizabethtown • Economy Shoe Store
Ephrata • Good's Variety
Erie • Carter's
Erie • Marshalls
Export • The Hub
Exton • Vision Quest
Franklin • Church's Boot Shop
Freeland • Freeland Outlet
Gilbertsville • Howard Merkle
Greencastle • Stickells General Store
Greensburg • M & M Shoe Repair
Greenville • Georges Bootery
Hamburg • Ely's Joy Footwear
Hanover • Super Shoes
Harrisburg • Picway
Hillsgrove • Penninger's Country Store
Johnstown • The Family Store
Johnstown • Picway
Kennett Square • Sheldons Department Str.
Kittanning • Larry's Boot Shop
Koppel • Linarellis Village Ctr.
Lancaster • Daniel Z. Stoltzfus
Lancaster • Davidson Shoe Corp.
Lancaster • Super Shoes
Latrobe • Army and Navy
Lebanon • Dinunzio's Shoe Repair
Lehighton • Obersons
Lock Haven • Math's
Loganton • Kaufman's Harness
Lower Burrell • Picway
Mc Adoo • Frank Kline
Meadville • The Boot Box
Mechanicsburg • Super Shoes
Mifflintown • Lost Creek Shoe Shop
Millersburg • Tall Pines Country Store
Mount Pleasant • Salooms Shoe Center
Muncy • Super Shoes
N. Huntington • M & M Shoe Repair
Nazareth • J & P Inc.
New Kensington • Bens
New Wilmington • Shelter Harness & Shoes
Palmerton • Sheas Hardware
Paradise • Knapp Shoes of Lancaster
Penn Hills • Patsy's Shoe & Sports
Pennsburg • Valley Shoe Center
Philadelphia • S.B. Harris
Pittsburgh • Abe Berstein Clothing
Pittsburgh • War Surplus
Quarryville • Books Shoe Service
Reading • Army & Navy Store
Reading • Super Shoes
Reedsville • Super Shoes
Rehrersburg • Leo's
Ridgeway • The Male Shop
Salladasburg • Cohicks Trading Post
Sayre • Harnold's A & N Store
Sayre • Thomas Shoe Store
Schuylhill Haven • Charles L. Geary
Scranton • B. Levy
Somerset • Army-Navy Discount
Somerset • Picway
St. Mary's • St. Mary's Boot Shop
Steelton • Cherry's Family Shoe Ctr.
Stroudsburg • Charlie's Shoe Service
Titusville • Keystone Mercantile
Torrance • Harold's A & N Store
Towanda • The Hub
Trevose • Trevose Family Shoes
Troy • Armenia Mt. Trading Post
Union City • Mandels
Uniontown • Picway
Washington • Picway
Waterford • Malec's Clothing
Wellsboro • Roy J. Dunham Inc.
West Chester • Jake Shure & Son
West Hazelton • Kaufman's Dept. Store
Whitehall • Army & Navy Store
Whitehall • Frank's Shoe Repair
Wilkes-Barre • Penn Lee Footwear
Williamsport • Mike's Place (2 Stores)
Willow Street • Warfel's Shoes
York • Super Shoes

RHODE ISLAND

N. Providence • The Shoe Horn
North Kingstown • Prague Shoes
Pawtucket • Apex Inc.
Providence • Adler Bros.
Smithfield • Factory Footwear Outlet
Warren • Jaimel's Shoe World
West Warwick • Jaimel's Shoe World
Woonsocket • Bullseye Shooting & Supply

VERMONT

Barre • Harry's
Bellows Falls • Sam's Dept. Store
Bradford • Hills 5 & 10
Brattelboro • Sam's Dept. Store
Enosburg Falls • J. & L Apparel
Hardwick • Trading Center
Middlebury • Lazarus Dept. Store
Morrisville • Arthur's Dept. Store
Morrisville • Miller's Country Outfitter
Norwich • Don & Whites
S. Burlington • Vermont Army & Navy
Springfield • Furman Shoe Place
St. Albans • Kaye's Shoe Store
St. Johnsbury • Caplans Army Store
St. Johnsbury • Harvey's Shoe Store
Vergennes • Fishman's Dept. Store
Wells Rivers • Burnham Shoe Store

THE GLIDDEN COMPANY - GLIDDEN PAINTS

Glidden products are available through nearly 10,000 independently owned retail outlets throughout the U.S.

HUSQVARNA FOREST & GARDEN

CONNECTICUT

Barrington • Craig's Power Equipment
Canton • Avon Equipment
East Granby • Walter M. Simmons & Sons
East Haven • East Haven Landscape
Groton • Johnson's Rental Center
Guilford • A & A Power, Inc.
Middletown • Midstate Tractor & Equipment
Newtown • Newtown Power Equipment
Ridgefield • Ridgefield Power Equipment
Southbury • Chainsaws Unlimited
Stafford Springs • Barrington & Chappell Co.
Torrington • R & S Rental & Sales

DELAWARE

Dover • B & M Small Engine
Stanton • Leasure's Lawn & Garden

MAINE

Auburn • Mooney's
Barre • Higgins Energy Alternatives
Buckfield • Briggs & Libby Sales & Service
Charlton • City Power Equipment
Dover-Foxcroft • Snow's A.G. & Saw Shop
Eliot • Seaward Inc.
Greenville Junction • Woodsmen Supply
Holliston • All Weather Equipment, Inc.
Houlton • Bill's Saw Shop
Kezar Falls • Herbert P. Eastman & Son
Lexington • Bob's Power Equipment
Lincoln • St. Pierre's Chain Saw Shop
Mars Hill • McCrum's Saw Shop
New Sweden • Jimmy's Chainsaw & Gun Shop
Northboro • Goodall's Power Equipment
Oxford • Reid's Service Station
Portland • Don's Power Equipment
Searsmont • Ames Farm Equipment Repair
Skowhegan • Finest Kind Saw Service
Springfield • Chainsaws of New England
Throndike • Dick Chase Sales & Service
W. Buxton • Wills & Son Sport Center
W. Farmington • Jack's Lodging Supplies, Inc.

MARYLAND

Annapolis • Baldwin's Small Engine
Chestertown • Charles Casey & Son
Frederick • Rentals Unlimited
Landover Hills • Kohler Equipment Co.
Timonium • Michael's Power Equipment

MASSACHUSETTS

Acushnet • Country Hardware & Repair
Belchertown • Devon Lane Farm Supply
Billerica • J.P. O'Connor Hardware
Brookfield • Quaboag Equipment Sales & Svc.
Butland • Overlook Services Inc.
Great Barrington • West's Farm Equipment
Halifax • Morgan's Power Equipment
Natick • Richey & Clapper, Inc.
Norfolk • Norfolk Power Equipment
Norton • Midway Power Equipment
Palmer • Palmer Saw Lawnmower Center
Pittsfield • Gingras Equipment
Shelburne Falls • Robert J. Ormond
West Concord • Moscariello Equipment

NEW HAMPSHIRE

Berlin • Labonville, Inc.
Bradford • The Lumber Barn
Center Conway • William F. Greene Saw Sales
Center Tuftonboro • Windy Ridge Corp.
Colebrook • Colebrook Chain Saw
Concord • Bunten's Saw Shop
East Kingston • James R. Rosencrantz & Son, Inc.
Errol • Baillargeon Chain Saw, Inc.
Goshen • Steve Fellows Chain Saws
Jaffery • Coll's Garden Center
Lebanon • Don's Sales & Services
Manchester • Superior Saw & Carbide Tool Corp.
Mason • J.T.'s Power Equipment
Nashua • R. White Equipment Center, Inc.
North Haverhill • Deb's Wheel & Deal Shop
Rochester • Colbath Equipment
Salem • Salem Building Supply Co.
Tilton • Perrin's Small Engine

NEW JERSEY

Chester • Erilake Equipment Co.
East Hanover • East Hanover Honda
New Monmouth • Brook Dale Mower
Point Pleasant • Beachboro's Saw & Mower
Sussex • Sussex County Power
Trenton • Apex Mower Service

NEW YORK

Barneveld • Dan Hudon Sales
Boiceville • Eisenbeil Rentals
Boonville • C.J. Logging Equipment
Callicoon • John H. Eschenberg
Canton • Woodchop Shop
Central Square • House Trucking
Chatham • Brook Cove
Chestertown • North Country Towing
Chestertown • William Trudsoe
Cold Spring • Cold Spring L/M
Cross River • Cross River Lawn & Garden
Dalanson • Organic Equipment
Delhi • McDowell & Walker, Inc.
Earlton • T & B Enterprises
Elmira • Pro-Home & Yard
Glens Falls • Smith Equipment
Glens Falls • This N That
Greene • Carl Pangburn
Hopewell Junction • Hutchinsons Equipment Co.
Massena • Lashomb's Saw Sharpening
Millerton • Brewers Mower Service
Mineola • Liffco Power Equipment
New Berlin • Rocky & Sons
New York • Edmunds Garden Power
Nineveh • Olivers S & S
Northville • Sacandaga Outdoor Equipment
Ossining • Ossining L/M Service
Riverhead • Riverhead Tool Corp.
Rosendale • B & S Hand Shop
Salem • Al Getty
Saratoga Springs • Yellens Powerhouse
Schroon Lake • Dave Whitty
Sparrow Bush • John's Mower Shop
St. Regis Falls • Caron' Sales & Service
Stanfordville • Eastern Saws
Troy • Garden Way
Troy • Garden Way Retail
Troy • Troy City Honda
Tupper lake • Fortier Chain Saw
Waterville • White's Farm Supply
Wilmington • Burdicks Chain Saws

PENNSYLVANIA

Belleville • Peachey's Saw Shop
Bodice • Barnard's Store
East Stroudsburg • Ray Hartman & Sons
Erie • Miller Brothers Garden Center
Everett • E & M Chain Saw Sales
Great Bend • Stones Hardware
Honesdale • Mike Tallman's Body Shop
Hughesville • Hill's L/M
Kane • Allegheny Logging Supply
Markleysburg • Sisler Equipment Co.
Oley • Bortz Chain Saw Shop
Smicksburg • Joe's Saw Shop
Somerset • Somerset Outdoor Equipment
Sweet Valley • David Moss Machinery

RHODE ISLAND

North Scituate • Gil's Power Mower Co.

VERMONT

Chester • Gordon's Small Engine
Morrisville • Leo's Small Engine
Orleans • Desmarais Equipment
St. Johnsbury • Greenwood Sales & Services
Waterville • Tobin's Small Engine
West Pairlee • Bob's Small Engine & Repair Shop
West Rutland • Chet Doaner Sales & Service
Wilmington • Greene's Power Equipment

KWIKSET® LOCKSETS

At hardware retailers, home centers and locksmiths everywhere.

LENNOX® INDUSTRIES INC.

For a Lennox dealer near you please call this number before June 30,1989: 1-800-232-3933

MARVIN WINDOWS AND DOORS

CONNECTICUT

Danbury • Northstreet Hardware
East Hampton • Lyon & Billard
Stamford • Stamford Insulation
Torrington • Torrington Sash & Door Company

MASSACHUSETTS

Agawam • Lucia Lumber
Berlin • Coldwell's
East Longmeadow • Rudolph Window & Door
South Deerfield • Elder Lumber
South Weymouth • Weymouth Lumber
West Upton • French Door & Window

NEW HAMPSHIRE

Bristol • R.P. Williams
Laconia • Groleau Millwork
Wolfeboro Falls • Winnipesaukee Lumber

NEW JERSEY

Middlesex • Perma-Seal Manufacturing
Middletown • American Lumber & Home Center
Union • Jaeger Lumber Company

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Look for the products featured in "The Home Remodeling Guide" at the stores listed below.

NEW YORK

Brooklyn • Brooklyn Window & Door Corporation
Buffalo • Big-L Distributors
Chatham • C.L. Smith
Cortland • J.T.s Lumber
Granite Springs • Jilco
Huntington Station • Window City, Inc.
Liverpool • Liverpool Lumber
Millwood • Millwood Supply
Moravia • LeHigh Lumber
Neversink • Superior Building Supply
Paris Station • Lincoln Davis Lumber Company, Inc.
Plattsburg • Airport Lumber
Poughkeepsie • Windsor Building Supply
Rochester • Jet Supply, Inc.
Saratoga Springs • Allerdice Building Supply
Sloatsburg • Geiger Lumber Company
Staton Island • A. Tranchina Company
White Plains • New Point of View

PENNSYLVANIA

Dingmans Ferry • C. H. Horns
Old Forge • Mariotti Building Products
Ottsville • Baumhauer's Design Center
Saylorsburg • Saylorsburg Lumber Company

RHODE ISLAND

North Kingston • F. J. Newman

MINWAX® CO.

Minwax products are available at all leading home center, hardware, and paint and decorating stores. For a free copy of "Tips on Wood Finishing" write to: Minwax Co., Dept. PS-049
P.O. Box 426
Little Falls, NJ 07424

OLYMPUS™ CORPORATION—THE INFINITY SUPERZOOM

CONNECTICUT

All Caldor Stores
All Camera Shop of NB Stores
All K-Mart Stores
All Lechmere Sales Stores
Stamford • Camera Wholesalers

DELAWARE

All Bambergers Stores
All Cameras Etc. Stores
All K-Mart Stores
All Ritz Camera Centers
Willmington • Cameras Ect.
Willmington • Lincoln Camera Shop

MAINE

All K-Mart Stores
Ellsworth • Camera & Photo Smiths
Freeport • L.L. Bean
Old Orchard Beach • Beach Camera Audio Video

MARYLAND

All Bambergers Stores
All Caldor Stores
All Jamesway Stores
All K-Mart Stores
All Ritz Camera Centers
All W. Bell Co Stores
Baltimore • Coopers Camera Mart

MASSACHUSETTS

All Ann & Hope Factory Outlets
All Apex Stores
All Caldor Stores
All Camera Shop of NB Stores
All K-Mart Stores
All Lechmere Sales Stores
All Perfecta Camera Stores
All Underground Camera Stores
Boston • Cameras Inc.
Boston • W.B. Hunt
North Dighton • Gaynes Department Stores

NEW HAMPSHIRE

All Jamesway Stores
All Lechmere Sales Stores
All Perfecta Camera Stores
Concord • Concord Camera

NEW JERSEY

All Bambergers Stores
All Caldor Stores
All The Camera Shop Inc. Stores
All Clover Stores
All Jamesway Stores
All Jersey Camera Stores
All Jewelcor Inc. Stores
All K-Mart Stores
Mahwah • Bennet Brothers
West New York • Giftime Discount
Westwood • Bergen County Camera

NEW YORK

All Berns Camera Stores
All Brothers Camera
All Caldor Stores
All 47th Street Photo Stores
All Jamesway Stores
All K-Mart Stores
All Lechmere Stores
Albany • State Photo
Binghamton • Tuthills
Brooklyn • Focus Camera
Buffalo • Delaware Camera Mart
Fishkill • Gaynes Department Stores
Lawrence • Labelle Province
Northport • Northport Camera
New York City • Adorama Camera
New York City • B&H Photo
New York City • Bi Rite Photo & Electric
New York City • Cambridge Camera
New York City • Executive Camera
New York City • Foto Cell
New York City • GCT Grand Central
New York City • Olden Camera
New York City • Photron Marketing
Rochester • Hahn Photographic
Rochester • Rowe Professional Photographic
Westbury • Westbury Camera

PENNSYLVANIA

All Bambergers Stores
All Caldor Stores
All The Camera Shop Inc. Stores
All Clover Stores
All David Wies Stores
All J.B. Dahlkemper Stores
All Jamesway Stores
All Jewelcor Stores
All K-Mart Stores
All Ritz Camera Centers
Bryn Mwar • The Camera Shop
Philadelphia • Jacks Camera Inc.
Philadelphia • Mid City Camera
Pittsburg • Basic Products
Pittsburg • Foto Hut
Stroudsburg • Stroudsburg Foto

RHODE ISLAND

All Ann & Hope Stores
All Apex Stores
All Caldor Stores
All Lechmere Sales Stores
All Save-Rite Stores
Warwick • K-Mart

VERMONT

All K-Mart Stores
Burlington • Abraham Inc.
Saint Johnsbury • Image North Inc.
South Burlington • Gaynes Department Stores

RAINDRIP, INC.

CONNECTICUT

Farmington • Lexington Gardens
Stafford Springs • National True Value Hdwr.

DELAWARE

Dover • Lowes
Millsboro • Bakers True Value Hdwr.
Rehoboth Beach • Lowes
Wilmington • Lowes

MAINE

All True Value Hdwr. Stores

MARYLAND

All Lowes Stores
Elliott City • Clark Hdwr.
Gaithersburg • Thomas W. Perry Servistar Hdwr.

MASSACHUSETTS

Cambridge • Lyons Garden Ctr.
Lexington • Lexington Gardens
Norwood • Simoni's True Value Hdwr.
Orleans • H.H. Snow & Sons

NEW HAMPSHIRE

Conway • Conway True Value Hardware
Jaffrey • Belletetes True Value
New London • Clark's Servistar Hardware

NEW JERSEY

Colts Neck • Becker True Value Hdwr.
Washington • Washington True Value Hdwr.

NEW YORK

Getzville • Arbordale Nursery
Pt. Washington • Lawberti Nursery, Inc.
Staten Island • East Coast Hydroponics
Westbury • Hicks Nursery

PENNSYLVANIA

Allentown • Triangle Bldg. Ctr.
Bethlehem • Triangle Bldg. Ctr.
Chambersburg • Triangle Bldg. Ctr.
Now Castle • Northern Lights
Pittsburgh • Northern Lights
Quakertown • Triangle Bldg. Materials
Wilkes-Barre • Triangle Bldg. Center
York • Triangle Building Center

RHODE ISLAND

All True Value Hdwr.

VERMONT

Burlington • Gardeners Supply Co.

RED DEVIL INC.

CONNECTICUT

Bridgeport • Grandfield True Value
East Haven • Channel
Farmington • Builders Square
Mystic • Mystic Lumber
New Haven • Whalley Ace Hardware
North Haven • Home Depot
Orange • Pergament
Waterbury • Grossman Store

DELAWARE

Claymont • Home & Garden Center
Dover • Moores Lake Hardware
Milford • Master Home Center
Wilmington • Mr. Goodbuys

MAINE

Belgrade • Hammond Lumber
Jay • Jay True Value
Lewiston • Polar Paint Inc.
Lisbon Falls • Aubuchon Hardware
Mechanic Falls • Handy Hardware
South St. Calais • Ellsworth Builders

MARYLAND

Baltimore • Bond True Value
Baltimore • Fisher's Hardware
Baltimore • HWI-Sandlers Paint
Baltimore • Mr. Goodbuys
Baltimore • National Lumber Co.
Beltsville • The Paint Store
Frederick • Frederick Trading Co.
Glen Burnie • Mr. Goodbuys
Leonardtown • Woods Paint & Wallpaper
Mt. Airy • Mt. Airy True Value
Pasadena • American Hardware Supply
Salisbury • C & P Hardware Co.
White Oak • Hardware City

MASSACHUSETTS

Acton • Somerville Lumber
Boston • Warren True Value
Brockton • Channel
Dartmouth • Builders Square
Dracut • Dracut True Value
Fitchburg • K-Mart
Fryeburg • Trumbull's Hardware
Gloucester • Building Center
Lowell • Lowell Lumber Co.
Lynn • Durant Paint
Shrewsbury • Spags
Somerville • Somerville Lumber Co.
Springfield • Grossman Inc.
Westfield • Agway
Westfield • American Hardware

NEW HAMPSHIRE

Gorham • Peras Ace Hardware
Hockset • Colonial Hardware
Nashua • Builders Square
Walpole • Perkins Home Center

NEW JERSEY

Bernardsville • Jaegar Lumber Co.
Bloomfield • Ricciardi Bros.
Bricktown • Mr. Goodbuys
Cranbury • Channel
Cranbury • Jamesway
Deptford • Grove True Value
Jersey City • Siperstein Paints
Livingston • Harry's Hardware
Lodi • Mr. Goodbuys
Lodi • Sipersteins Paint
Madison • Jaegar Lumber
Paramus • Pergament Corp.
S. Plainfield • Rickel Home Center
Springfield • Kay's Hardware
Toms River • K-Mart
Trenton • Mr. Goodbuys

NEW YORK

Florida • Roe Brothers Lumber
Fredonia • Value Home Center
Garden City Park • Pergament
Ithaca • Agway
Middletown • Grossman Store
N. Tonawanda • Valu Home Center
Oneida • Agway Lumber & Bldg. Ctr.
Pawling • Dills Best Bldg. Ctr.
Poughkeepsie • Davies Hardware
Poughkeepsie • Montgomery Wards
Rome • American True Value
Schenectady • Mahoney's True Value Hardware
Staten Island • Tomlinson Hardware
Tonawanda • Mr. Second Lumber
Westbury • Mr. Goodbuys

PENNSYLVANIA

Allentown • Triangle Bldg. Centers
Bethlehem • Triangle Bldg. Centers
E. Butler • American Hardware
Elizabethtown • Agway, Inc.
Erie • Value Home Center
Greensburg • Westmoreland Supply
Hanover • Lowe's PA
Johnstown • Dravis Lumber
Lancaster • Leaner True Value Hardware
McKeesport • GC Murphy Co.
Philadelphia • Mr. Goodbuys
Pittsburgh • Busy Beaver
York • Triangle Bldg. Centers

RHODE ISLAND

Cranston • Channel
Smithfield • Douglas Lumber
Wakefield • Damons Hardware

VERMONT

Highgate Spring • Fred Meyers
S. Barre • Barre Home Supply
Waitsfield • Valley Paint

SKIL® POWER TOOLS

ALL STATES

Ace Hardware Stores
Builders Mart Stores
Channel Home Centers
Coast-to-Coast Stores
H.W.I. Stores
Pro Hardware Stores
Sentry Hardware Stores
Servistar Hardware Stores
True Value Hardware Stores

CONNECTICUT

Bethel • Rings End of Bethel
Darien • Rings End Inc.
New London • Miner & Alexander Lumber
New Milford • Diamond Lumber
North Haven • Price Club
Waterbury • J E Smith & Company

DELAWARE

Elsmere • A H Angerstein Inc.
Laurel • Dukes Lumber Company
Milford • D & R Distributors

MAINE

Ellsworth • Ellsworth Builders

MARYLAND

Baltimore • National Lumber
Cumberland • Buchanans Lumber
Glen Burnie • Price Club
Hagerstown • Hagerstown Lumber
Reisterstown • Reisterstown Lumber

MASSACHUSETTS

Ayer • G V Moore Company
Brockton • Lawrence Paint & Hardware
Falmouth • Wood Lumber
Foxboro • Chace Building Supply
Gloucester • Building Center Store
Granby • Street Lumber Corporation
Haverhill • Harvey TV Lumber
Lawrence • Jackson Lumber Company
Norwell • Dougherty Building Supply
Rockport • Building Center
Salem • Rich's Warehouse
Wellesley • Diehl F & Sons

NEW HAMPSHIRE

Manchester • Diamond Lumber Company
North Conway • Chick Lumber

NEW JERSEY

All Peter Lumber Stores
Beach Haven • Crammer Lumber
Bridgeton • H H Hankins & Brothers
Cherry Hill • Haddonfield Lumber Company
Columbus • Stevenson Lumber
Edison • Price Club
Morristown • Armstrong Building Supply
Trenton • Heath Lumber Company

NEW YORK

All Hectors Hardware Stores
Batavia • Genesee Lumber
Brooklyn • Doody Hardware
East Syracuse • East Syracuse Hardware
Hornell • Hollands Lumber
Middletown • Miller Building Supply
Middletown • Rowley Coal Lumber Co.
Mineola • Lathan Brothers
New York City • D & W Enterprises
New York City • SGD Corporation
Sherburne • Webb & Sons Inc.
Spring Valley • Beckerle Lumber Supply
Staten Island • Doody Home Center

PENNSYLVANIA

All Cramers Cashway Stores
Kennett Square • Peter Lumber
Lancaster • Johannings
Milton • Clinger Lumber
Norristown • March Fairview Lumber
Norristown • March & Kneas Lumber
Philadelphia • Dubin Brothers
Philadelphia • Herman Hardware
Philadelphia • Major Plumbing Spec.
Philadelphia • Peter Lumber
Philadelphia • Precision Equipment
Pittsburgh • Daniels Hardware
Pittsburgh • Stanford Home Center
Pottstown • A D Moyer Lumber
Roslyn • Geppert Lumber
Somerset • SDC Building Center
State College • Lezzer Lumber
West Chester • J. Leon Hagerty

RHODE ISLAND

Johnston • Grossman's

VERMONT

Burlington • TA Haigh Lumber
Rutland • Mintzer Brothers

TRIPOD INTERNATIONAL CO.

MARYLAND

Annapolis • Montgomery Ward
Bel Air • Montgomery Ward
Catonsville • Montgomery Ward
Frederick • Montgomery Ward
Glen Burnie • Montgomery Ward
Hagerstown • Montgomery Ward
Hyattsville • Montgomery Ward
Laurel • Montgomery Ward
Rosedale • Montgomery Ward
Salisbury • Montgomery Ward
Temple Hills • Montgomery Ward
Towson • Montgomery Ward
Wheaton • Montgomery Ward

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WHERE TO BUY LISTING

Look for the products featured in "The Home Remodeling Guide" at the stores listed below.

NEW YORK

Ithaca • Montgomery Ward

PENNSYLVANIA

Carlisle • Montgomery Ward
York • Montgomery Ward

RALPH WILSON PLASTICS CO., INC. (WILSONART®)

CONNECTICUT

Stratford • Connecticut Plywood Corp.
West Hartford • Connecticut Plywood Corp.

MAINE

Bangor • Bangor Wholesale Laminates
Portland • Winde-McCormick

MARYLAND

Salisbury • Dealers Building Supply Corp.

MASSACHUSETTS

Falmouth • Alco Distributors
North Reading • Frederick Shohet, Inc.
W. Springfield • L & R Sales, Inc.
Worcester • L & R Sales, Inc.

NEW HAMPSHIRE

Londonderry • Frederick Shohet

NEW JERSEY

Fairfield • NYMMCO, Inc.
Middlesex • NYMMCO, Inc.
Pennsauken • Ralph Wilson Plastics

NEW YORK

Albany • Millwork Specialities, Inc.
Astoria • New York Metal
Binghamton • Tri-City Wholesale
Farmingdale • New York Metal Moulding Co.
Farmington • Babcock Lumber Company
Jamestown • Eastern Plywood Corporation
Lancaster • Babcock Lumber Company
Syracuse • Woodland Specialities, Inc.

PENNSYLVANIA

Altoona • Babcock Lumber Company
Clarion • Soice, Inc.
Old Force • Mariotti Lumber Co.
Pittsburgh • Bennett Supply Co.
Temple • Bun Patch Supply Corp.
West Chester • Paco Distributors

RHODE ISLAND

Central Falls • Crest Distributors

VERMONT

Burlington • Acme Paint & Glass

CANADA/NEW FOUNDLAND

St. Johns • Provincial Woodproducts

NOVA SCOTIA

Dartmouth • Laminates Plus

QUEBEC

Chomedey • SIMTAB Marketing Svc.

AUSTRALIA

Belmont, Western Australia • Parburys Building Prod.
Brisbana, Queensland • Parburys Building Prod.
Smithfield, New South Wales • Parburys Building Prod.
Springvale, Victoria • Parburys Building Prod.
Woodville, South Australia • Parburys Building Prod.

BAHAMAS

Nassau • Omni Supplies Ltd.

BERMUDA

Hamilton • Gorham's Limited

HONG KONG

Hopewill Trading Co.

SINGAPORE

Formwell Products Pte.

TAIWAN

Taipei • Gateway Enterprises Ltd.

WING INDUSTRIES, INC.

ALL STATES

All Brewsters Stores
All Builders Square Stores
All Carter Lumber Stores
All Cash Home Centers Stores
All Diamond Lumber Stores
All Dills Best Stores
All 84 Lumber Stores
All Golden Rule Dealers Stores
All Grossman's Stores
All Hechinger Co. Stores
All JT's Home Centers Stores
All Lloyd Home & Bldg. Centers Stores
All Lowes Stores
All M.L. Claster's Lumber Stores
All Moore's Stores
All P.F. O'C Stores
All Somerville Lumber Stores
All Valu Home Center Stores
All Builder Marts of America Stores
All True Value Stores
All H.W.I. Stores
All Liberty Distributors Stores
Most Servistar Corp. Stores

CONNECTICUT

Derby • Housatonic Lumber
Franklin • I.T. Dealers
Waterbury • Waterville Lumber

DELAWARE

Claymont • Beautiful Home Center

MARYLAND

Gaithersburg • T.W. Perry

MASSACHUSETTS

Braintree • Servistar Hardware
East Dedham • Prudential Metal
Holyoke • Tessier Lumber
Lowell • Friend Lumber
Lunnenburg • Maki Home Center
Somerset • Horner Millwork
Watertown • Nonantum Home Center
Westfield • Wood Shed

NEW JERSEY

Williamstown • The Woodworks

NEW YORK

Brooklyn • Monarch Millwork
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Submersible acrobat

By PETER BRITTON
Illustration by Bob Lange

Seals swimming in San Diego harbor might gawk in surprise— possibly envy—at Scorpio Scout, a torpedo-shaped remotely operated vehicle (ROV) recently tested underwater there. The Scout's tandem propellers enable it to hover beneath the waves like a helicopter—or roll, pitch, yaw, surge, heave, and sway like an acrobatic seal. Such dazzling agility makes the 200-pound ROV a good candidate for sophisticated new mine-hunting vehicles (see illustration below).

Inventor Ted Haselton created the system with off-the-shelf hardware. "It's a radical departure from conventional propulsion systems, but it uses well-known theory and technology," he says. Haselton, a former submariner, conceived of tandem propellers with variable-pitch blades in the 1960s. Some early goals for this exotic form of propulsion: stabilize subs for missile launches or to enable rescue vehicles to hover deep in the ocean. Although the U.S. Navy adapted different technology, Haselton continued to refine his design. "As with most hydrodynamics innovations," he says, "the tandem propeller system was too much too soon."

Current designs use two identical six-bladed propeller hubs located near the ends of the hull. Each Scout propeller hub is turned by a two-horsepower brushless DC motor. An on-board battery or external cable supplies power.

Haselton put a swash-plate mechanism into the Scout that enables all the blades to change pitch within one rotation. When all blades are set to the same angle at once, they produce a forward surge; reversing the pitch generates aft movement. But the Scout's unique maneuverability is controlled by an on-board microprocessor. The computer can vary the pitch of each blade during a propeller revolution. Cross forces—not along the Scout's axis—produce the agile movements.

Says ROV product manager Alvin Cerveny of Ametek in San Diego, now producing the vehicle: "Using the maneuverability of two Scorpio Scouts an experienced sonar operation can 'paint' a picture of a mine for definitive identification." PS

Two tandem-propeller Scouts on a central chassis housing a Plessey sonar form a tethered remotely operated mine-hunting vehicle. The vehicle, equipped with explosive charges, could stop quickly and hover, sweeping its sonar beam over suspected targets. Above, a Scout is lifted from a tank.

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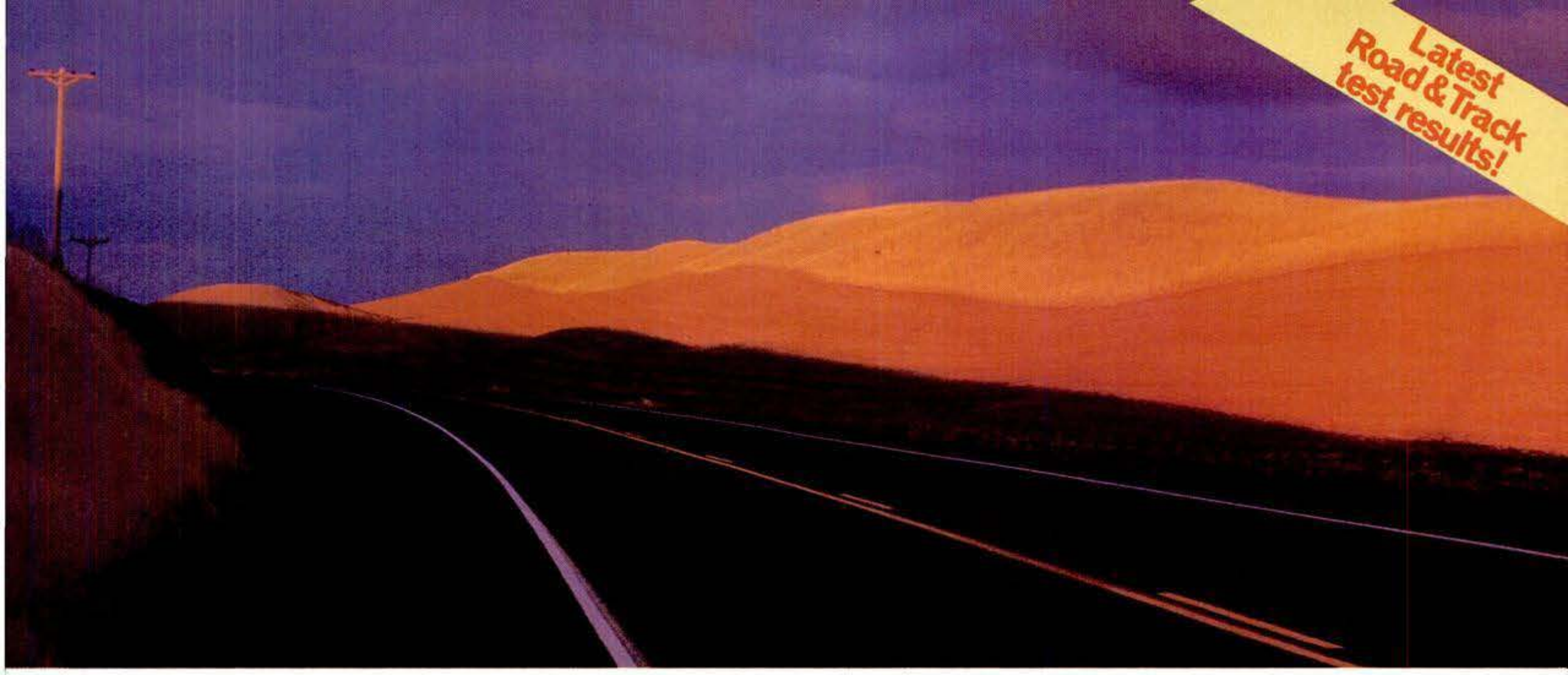


Highest K And X Band Sensitivity

Road & Track, Nov. 1988

Model 976

BEL VECTOR 3 Radar Detector

In *Road & Track*'s recent test of currently available radar detectors, BEL VECTOR 3 rated number one in both K and X band sensitivity. Rarely is one radar detector best in both K and X bands. In fact, VECTOR 3 posted the highest K and X band sensitivity levels ever recorded! The results confirm BEL's performance advantage:

"...Vector 3 maintains a BEL tradition of excellent sensitivity, posting the highest figures in this survey for both K and X band radar." *Road & Track, Nov '88*

It's now clear. BEL technology offers unmatched performance. And with today's sophisticated radar equipment, nothing is more important than the best possible performance.

VECTOR 3's performance edge is achieved by adapting a technology used in military satellite communications. We call it Image Rejection Technology®, or IRT®. And through its use, VECTOR 3 provides a level of sensitivity unequaled by any other radar detector manufacturer—a definite advantage for detecting Instant On or Pulsed radar. And when Instant On or Pulsed radar is encountered, VECTOR 3 warns you with a separate audio alert.

But outstanding sensitivity isn't your only advantage. VECTOR 3 also detects Ka band radar, now increasing in use throughout the U.S. and Canada. And VECTOR 3 also effectively reduces false alerts from non-police sources without any loss of sensitivity to police radar.

Laboratory Tests*

Model	Sensitivity, dBm/cm² X-band	K-band
BEL Vector 3	117.2	115.6
Audiovox RX-4	104.1	93.9
Cincinnati Microwave Escort	112.9	106.8
Cincinnati Microwave Passport	114.1	107.8
Cobra Trapshooter RD-3170	113.4	110.8
Fultron 15-0900, Snooper D-4000	109.4	108.8
Kraco KRD-16	102.7	104.7
Mascot PH222	101.5	94.6
Maxon RD-25	109.3	106.8
Radio Shack Micronta Road Patrol XK	107.6	106.0
Uniden RD9XL	113.1	108.8
Whistler Spectrum 2	115.6	110.4
Average unit	110.1	106.3

Source: Road & Track, Nov. 1988

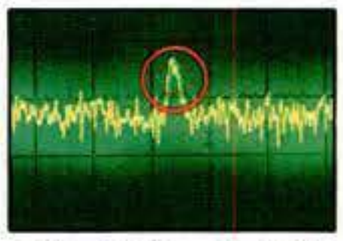
*Conducted by Advanced Product Evaluation Laboratory, Inc.

BEL VECTOR 3 is the only unit in this test that also detects Ka band radar.

The IRT® Difference

A police radar signal is often buried by microwave "noise", making it invisible to ordinary superheterodyne detectors. Image Rejection Technology® however, reduces this surrounding microwave "noise" making the same police radar signal visible for early detection.

How a conventional superheterodyne radar detector sees a police radar signal.



VECTOR 3 with IRT® sees the same signal clearly by reducing microwave "noise".

Performance this complete also includes a long list of features that makes driving with VECTOR 3 easy and convenient.

VECTOR 3 is only **$279.95** and comes with a full one year warranty on parts and service. To order your VECTOR 3, or to obtain the name of a dealer near you, just call toll-free.

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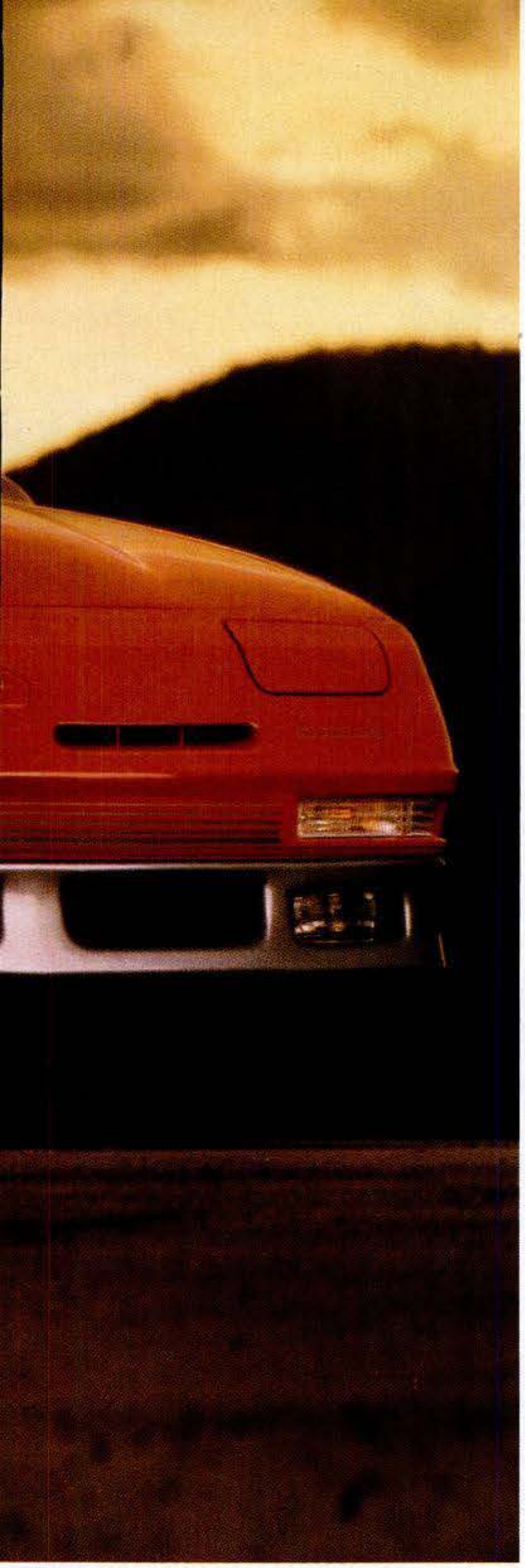
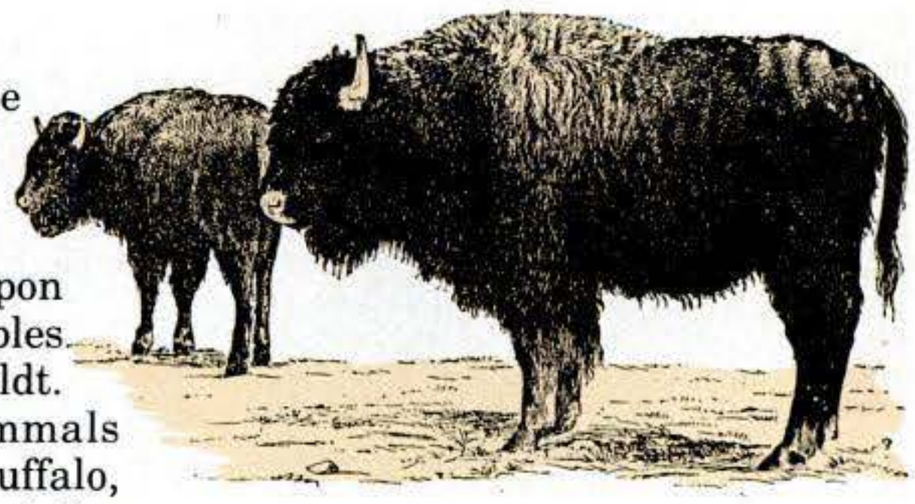


Looking Back...

Sampling a century of POPULAR SCIENCE

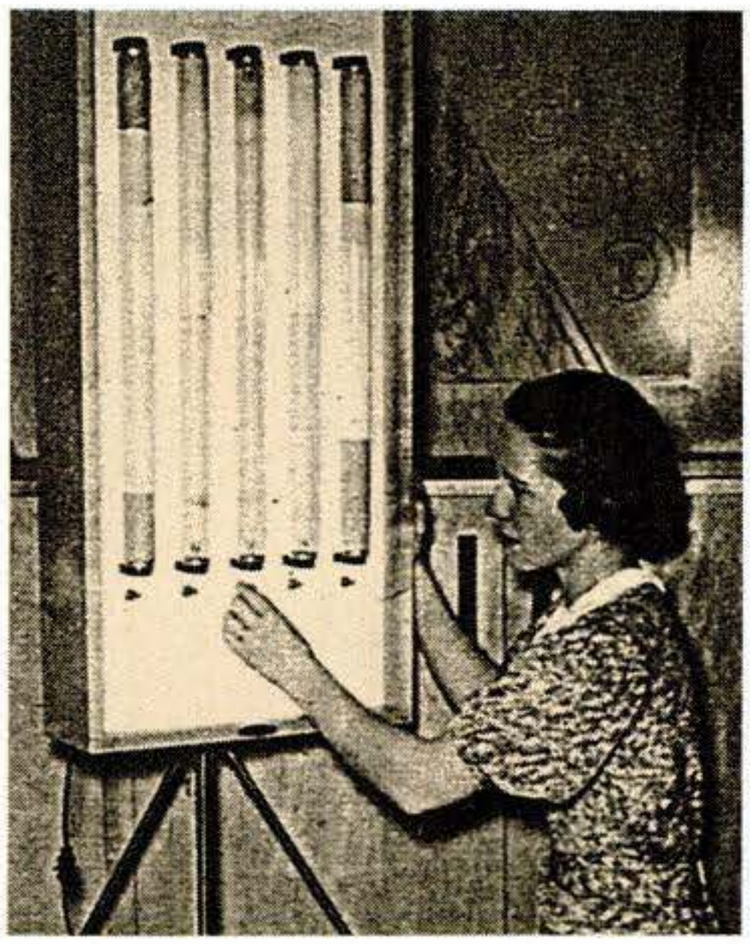
100 YEARS AGO — APRIL 1889



"The day will come when all of our larger mammals will cease to exist in nature, and we shall have to depend upon our gardens and parks for examples of them," wrote Dr. R. W. Shufeldt. "Among the endangered mammals none is better known than the buffalo, though the Rocky Mountain goat, the beaver, and several species of deer stand in the same case. Of the birds, it can be only a few years at most until our Carolina parakeet and roseate spoonbill are extinct in this country."

It took longer than predicted, but the Carolina parakeet was presumed extinct by 1970. The colorful bird snacked on fruit grown by settlers in eastern North America.

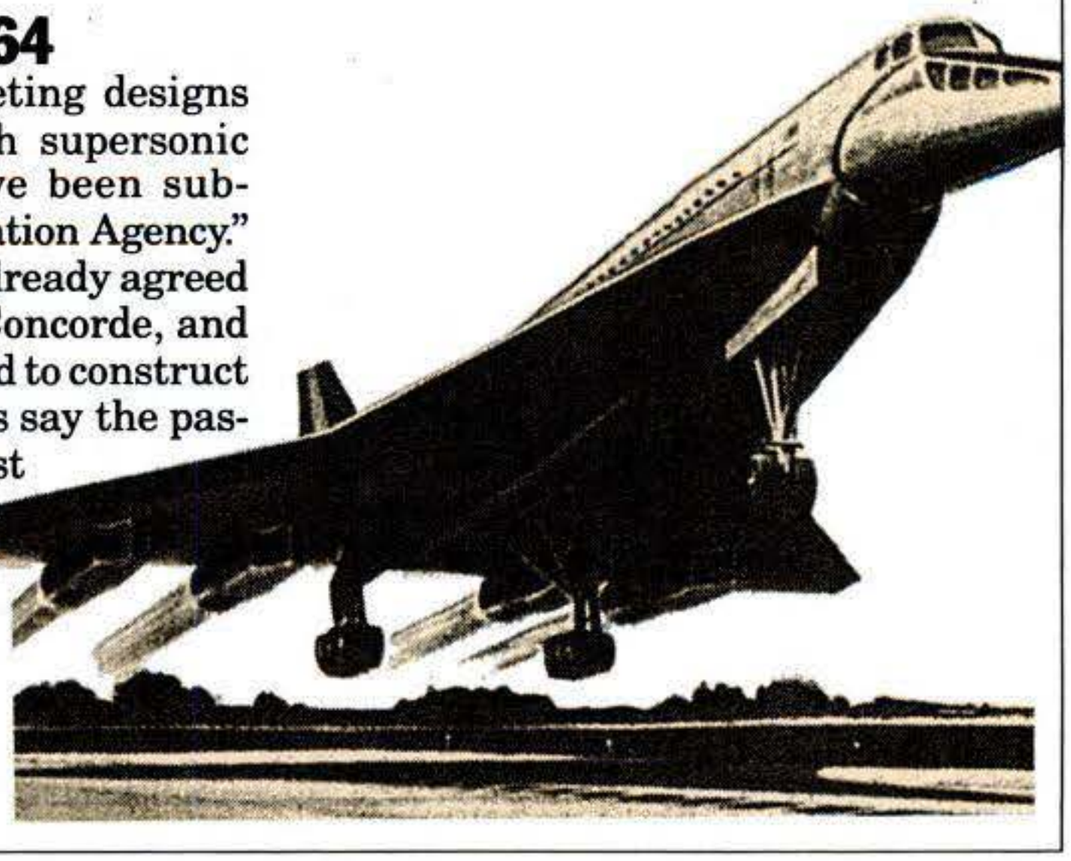
50 YEARS AGO — APRIL 1939



"Magic wands of 'cold' light, rivaling the rainbow in their hues and the firefly in their efficiency, have come out of the laboratory to paint night scenes with new marvels of beauty. Perfected and ready for use after years of experiment by General Electric research engineers, these 'fluorescent lamps,' as they are called, apply a brand-new principle in illumination.

"Visitors to California's International Exposition are viewing the spectacular debut of the new departure in lighting." Along with the colored tubes designed for electric signs, engineers introduced a "daylight" shade, "declared to be man's closest approach to natural light."

25 YEARS AGO — APRIL 1964



"Three competing designs for 2,000-mph supersonic airliners have been submitted to the Federal Aviation Agency." Britain and France had already agreed to build the 1,450-mph Concorde, and American officials wanted to construct a rival SST. "Some critics say the passenger has little interest in being 'shot' to his destination, and that the SST will lay 'boom carpets' across the land." Of the designs only the Concorde was ever built.

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Popular Science

What's News

High-tech housing

I was recently reading through the 100th anniversary issue of POPULAR SCIENCE published in May 1972 when I ran across a piece on factory-built housing. It pointed out that high-quality housing could be fabricated in a factory, then assembled on site at a lower cost than stick-built houses. Further, the quality could be higher because everything could be built in precision jigs, and more automatic machinery generally means better construction. Houses fabricated in the factory can be of any design you choose, and once up, are indistinguishable from houses built by conventional on-site sawing, fitting, and nailing. They'd go together rapidly on the site, because complete walls containing all wiring, plumbing, and air conditioning would be assembled in the factory. Finally, the process is not subject to the vagaries of weather and could make use of relatively unskilled workers. Altogether, we said, factory-built housing would surely be a fierce competitor in the marketplace and would no doubt dominate the home-building industry in a relatively short time.

It didn't happen. Not in the United States. It did in Japan and the Scandinavian countries [May '85]. But not here. Why not? It's hard to say. The home-building industry is certainly extremely conservative. Building codes interfere in some places. No giant home-building companies have evolved here as they have in Japan, making houses on a scale that justifies building expensive plants in which to fabricate wall panels and other major components.

The Builders' Show

All of this was very much on my mind recently as I walked through the miles of aisles at the annual meeting of the National Association of Home Builders in Atlanta, because what I saw was a rising interest in new housing technology. The Smart House people [Aug. '88] were on hand with advanced displays of the technology that's going into laboratory and prototype Smart Houses this year and into real houses that real people will live in within the next two years. The Electronics Industry Association was there with its CEBus standard—an electronic protocol designed for people making home equipment so that one piece of equipment can talk to another. With standardized CEBus equipment in your home, for example, you could query your TV set with your hand-held controller to determine what the thermostat was set at, then change the setting without leaving your chair. You could turn appliances on or off, and you could have the TV set in touch with the home communications system so that the volume automatically lowered when you picked up the phone. Smart House and CEBus are both aimed at giving us ways to interact with our homes in different and more-convenient patterns.

Plastic-house update

Another indicator: General Electric had a large display of its approach to the use of structural plastics in home building [Aug. '88]. There were large crowds around and much interest in this advanced technology that could bring about profound changes in the way our homes are built, ultimately giving a golden combination of better quality, greater ease and speed of construction, more utility and flexibility, and lower cost.

Examples were on hand in every direction:

- Microprocessors continue to proliferate in appliances of all kinds.
- More-efficient high-tech windows are everywhere. Marvin, a leading window maker, announced that all windows ordered with low-emissivity glass would henceforth also be filled with argon gas at no extra cost, bumping up R-values by a full point.
- Flexible gas piping that will lower installation costs and make gas readily available anywhere in the home is halfway through its U.S. code approval.
- Two new all-in-one devices packaged many functions now usually distributed in separate appliances. A heat pump supplies heating, cooling, ventilation, and humidification or dehumidification. And the heat normally thrown away during the air-conditioning cycle is used to heat water free. Expect to see more equipment embodying this everything-in-one-package principle in the near future.
- Every upscale housing exhibit had closets containing carrousel units similar to those at your local dry cleaner, but scaled to give more efficient use of the closet. These were shown for the first time at last year's show, but are now close to being standard equipment.
- Fascinating new materials were everywhere: from a handsome resilient floor covering made from, of all things, ground up old tires; to a beautiful wood flooring that helps soundproof the house; to an ingenious rubbery material that goes up quickly on the outside of a home, adhering to concrete, wood, or foam insulation, and having the look of classic stucco.
- High technology is definitely in. Even things that weren't truly high tech imitated those that were. Kitchen appliances, for example, showed a strong trend toward the flush Eurolook, which has a high-tech appearance even though most of them work exactly like their low-techier-looking counterparts.

Stories to come

Altogether, it was a remarkable show. And a huge one. Three POPULAR SCIENCE reporters spent a total of 10 days walking through the hundreds of exhibits, talking with the inventors, engineers, and manufacturers in attendance. We found much that will interest you—too much by far to cover in a single issue or even several issues. So for the indefinite future, we expect each issue to contain a good selection of articles about the products and processes that are changing the homes we live in and thereby the way we live our lives.

C. A. Fillmore

Editor-in-Chief

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A leap of the imagination leads to powerful new microscopes that provide unprecedented images of the unseen world.

SEEING

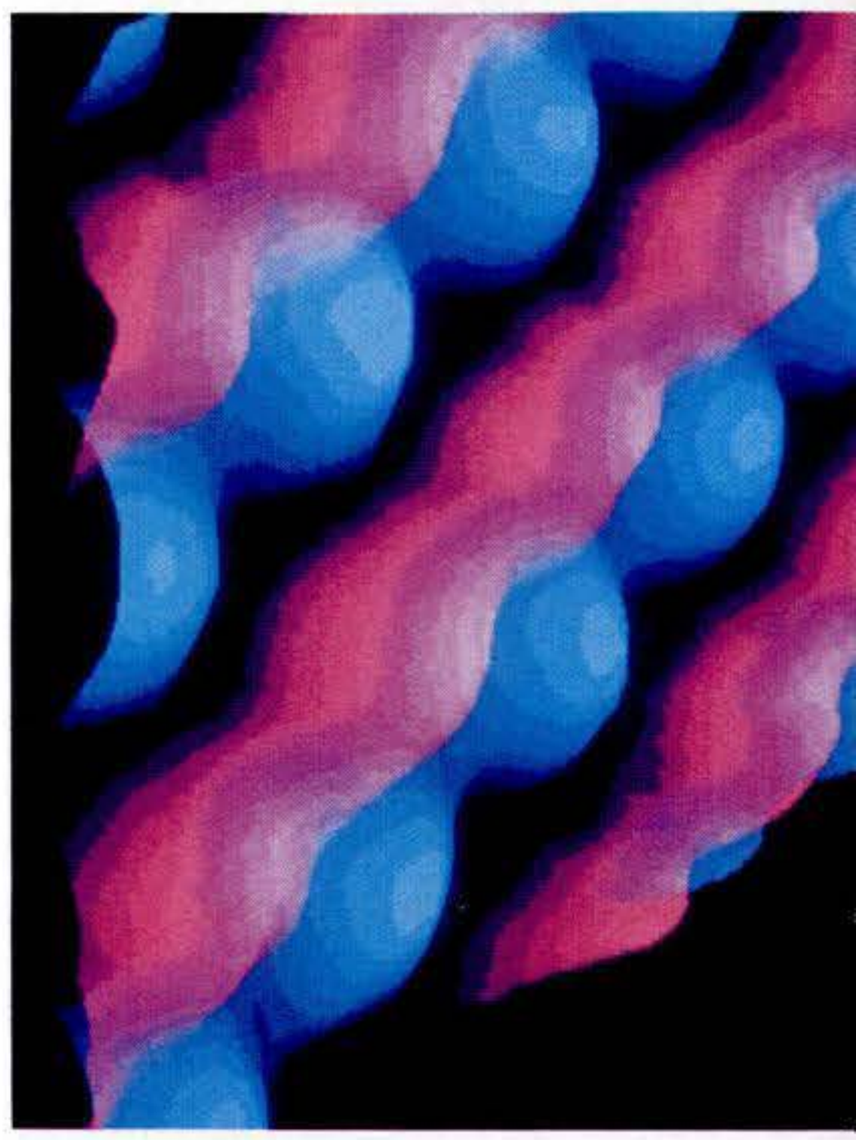
By ARTHUR FISHER

You could say it all started with Anton van Leeuwenhoek—the quest for the subvisible. True, others had developed crude microscopes before his, the credit generally going to three Dutch spectacle makers around the turn of the 17th century. But it was the crusty Delft dry-goods dealer van Leeuwenhoek who first actually saw, through his miraculous lenses, things so small that they had never been dreamed of before, much less seen.

For on one signal day in 1674 he peered through a microscope of his own making at a drop of rainwater and was amazed to see, wriggling and scooting about, "very little animalcules"—living creatures we know now, from his descriptions, to be bacteria and protozoa. They were so tiny he reckoned that one of them was a thousand times smaller than the eye of a large louse. And he wrote to the flabbergasted Royal Society in London that one drop of pepper water contained 2,700,000 of the strange beings.

One of Leeuwenhoek's microscopes in the museum of Utrecht has a power of 275×, and a resolution close to one micron (one-millionth of a meter).

Today, a series of stunning advances has culminated in microscopes able to distinguish individual atoms whose diameter is only about one angstrom—one ten-billionth of a meter, or about four-billionths of an inch. (Typical atomic diameters range from about one to three angstroms.) These incredible devices are the scanning tunneling microscope, or STM, and its younger relative, the atomic force microscope, or AFM. The images of atoms



and molecules on these pages are their products.

So significant is the potential of the STM (and its offspring) that it is only the fourth invention to garner a Nobel Prize in Physics since the award was first given in 1901. For the first time, scientists can not only map the detailed atomic structure of a surface, but explore the electronic properties of its atoms individually. Such analytical power will be invaluable to microchip designers, electrochemists, and molecular biologists, to cite just a few beneficiaries.

The co-inventors and recipients of half the 1986 prize were Heinrich Rohrer and Gerd Binnig, of IBM's Zürich Research Laboratory in Switz-

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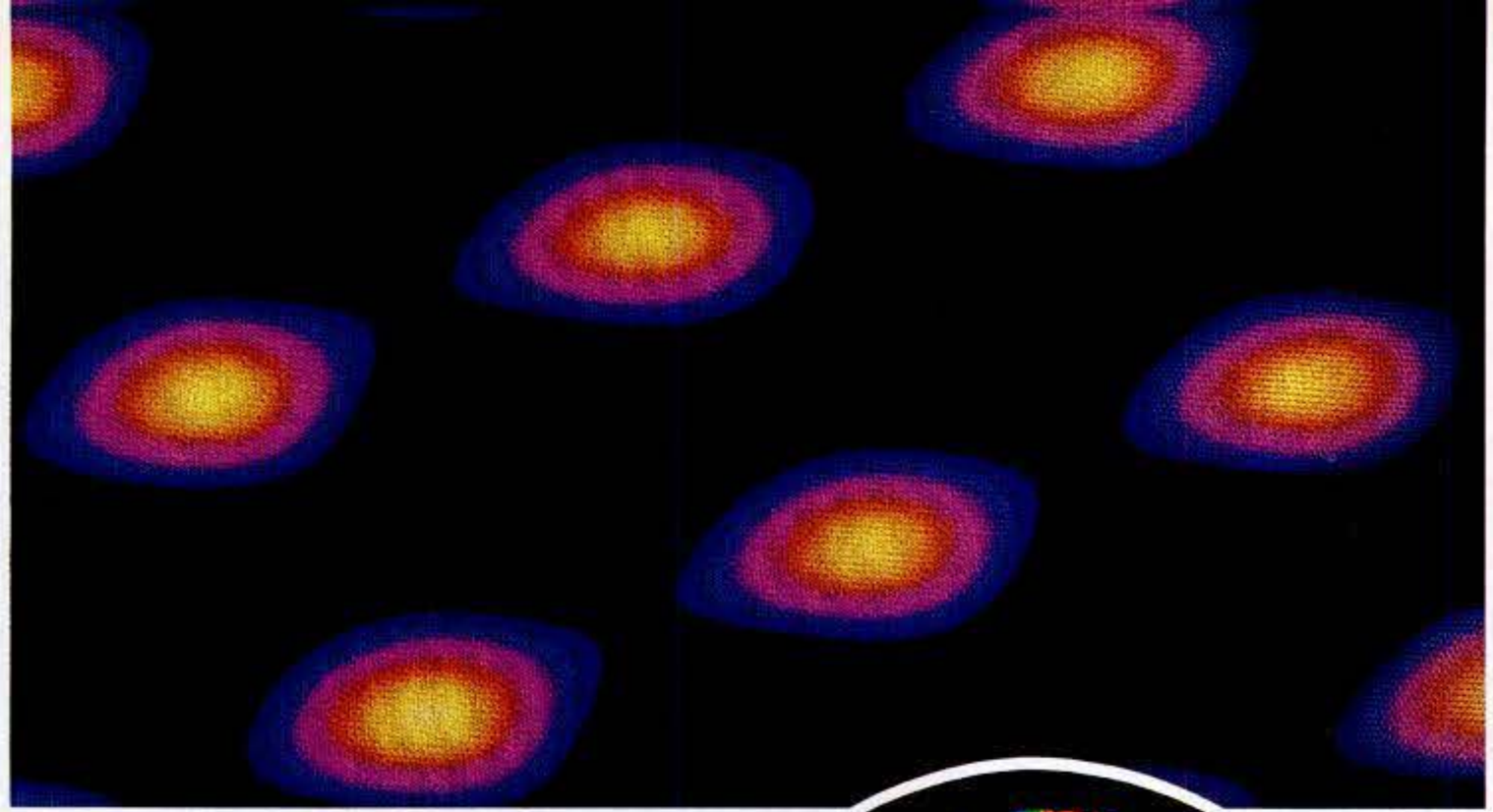
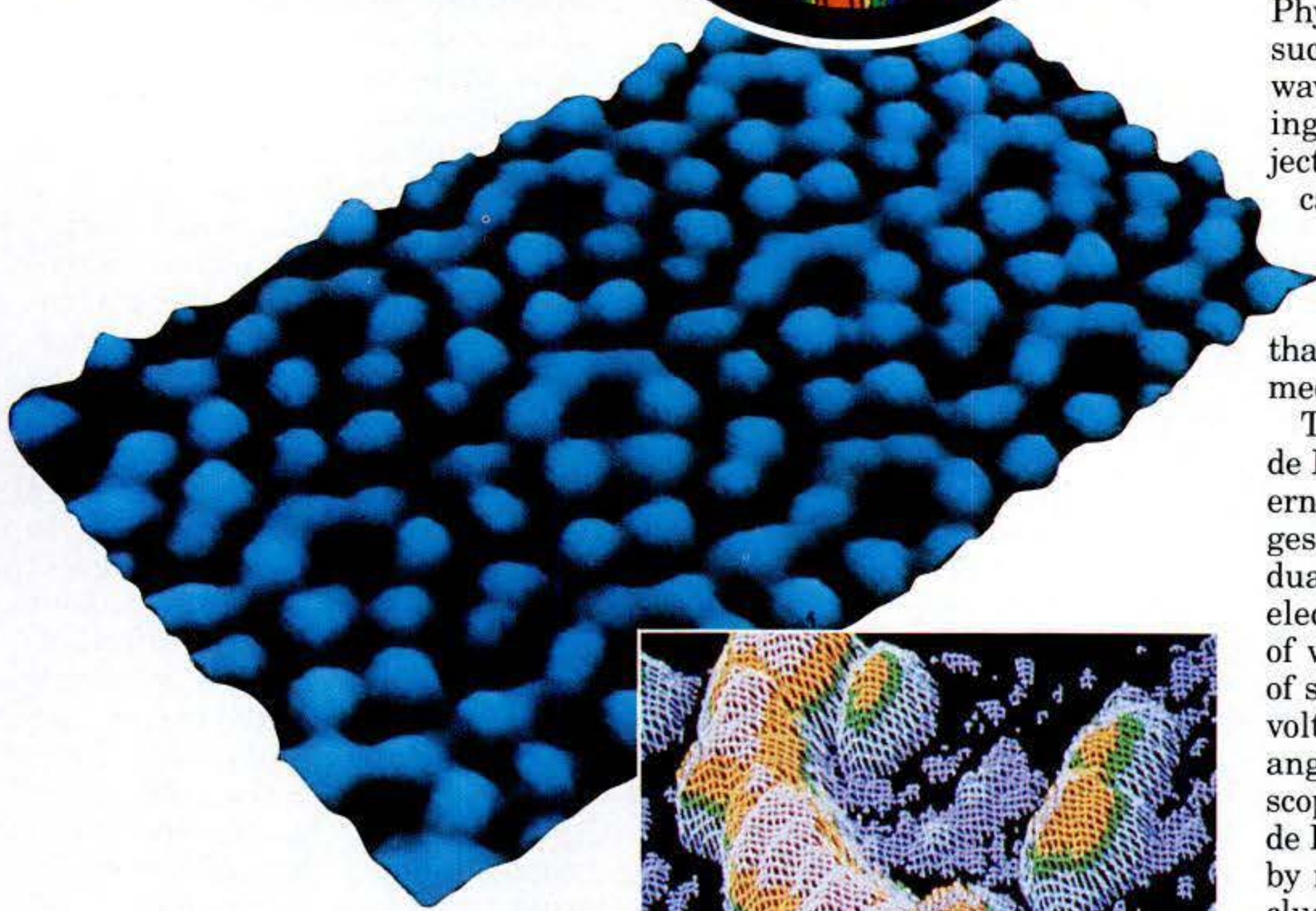
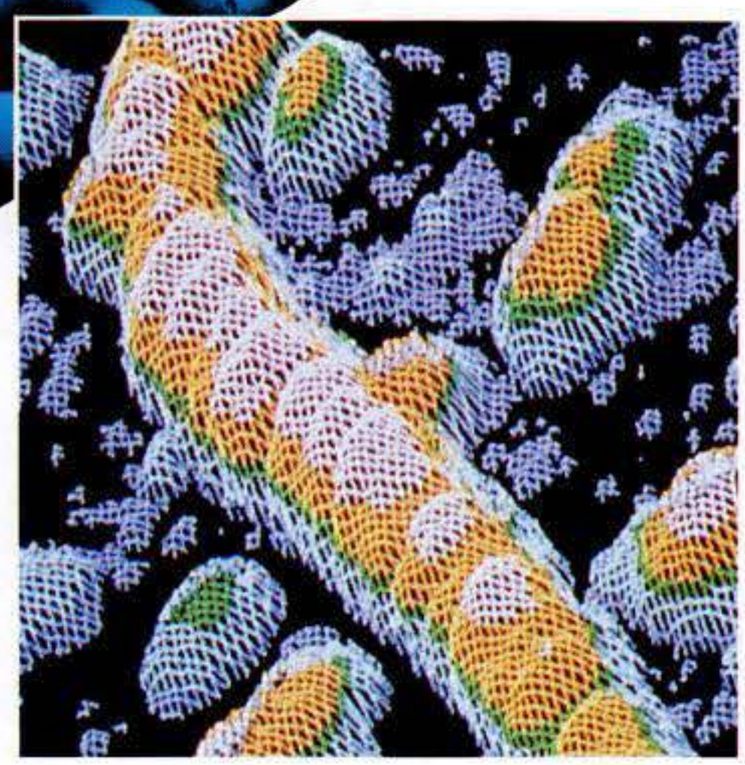


Atoms and molecules imaged by the scanning tunneling microscope (STM) and the atomic force microscope (AFM). Previous page: gallium arsenide, with gallium atoms in blue and arsenic in red (STM, IBM Research Laboratories, Yorktown Heights, N.Y.); this page, top to bottom: individual molecules of the amino acid leucine (AFM, University of California, Santa Barbara); graphite surface with raised carbon atoms in white (AFM, UCSB); computer-processed 3-D image of silicon surface (STM, IBM Research Laboratories, Yorktown Heights); recA-DNA complex molecule, metal coated (STM, IBM Zürich Research Laboratory).

ATOMS





erland. The other half of the 1986 prize went to Ernst Ruska of the Fritz Haber Institute in West Berlin "for his fundamental work in electron optics and for the design of the first electron microscope." The 80-year-old physicist had described that instrument a mere 55 years before. The STM was developed 50 years later, and thus received quick (for a Nobel) recognition.

In announcing the joint award, the Swedish academy said that the significance of the electron microscope "in different fields of science such as biology and medicine is now fully established: It is one of the most important inventions of this century."

As for the STM: "The scanning tunneling microscope is completely new, and we have so far seen only the beginning of its development. It is, however, clear that entirely new fields are opening up for the study of matter."

Like the electron microscope, the STM depends on the properties of electrons, and for the same reason. The resolving power of any instrument depends on the wavelength of the energy it uses to visualize a small object. Physical law demands that the size of such an object be no smaller than one wavelength of the radiation illuminating it. That means the smallest object a conventional optical microscope can see is limited by the wavelength of visible light to about 2,000 angstroms (about 1/250,000 of an inch). To resolve anything smaller than this—a virus, for example—some medium other than light is needed.

The answer came when Prince Louis de Broglie, one of the pioneers of modern physics and a Nobel laureate, suggested in 1924 that electrons had a dual, wave-particle nature. A beam of electrons could be regarded as a form of wave motion. And the wavelength of such a beam accelerated by 60,000 volts would effectively be only 0.05 angstrom. The first electron microscopes, built in the 1930s, embodied de Broglie's insight, and were followed by many sophisticated variations, including the scanning electron microscope ["The Invisible World in 3-D," April '70].

The STM also relies on the dual nature of electrons, using a quantum-mechanical phenomenon called tunneling, in which electrons apparently bore through barriers (insulators, for example, or a vacuum) in ways that defy classical physics. (For his description of tunneling in superconductors, the British physicist Brian Josephson shared the 1973 Nobel Prize in Physics.)

If two conducting surfaces are brought close together, the electron waveforms, or clouds, surrounding their atoms will overlap. If a small voltage is applied between the conduc-

Continued

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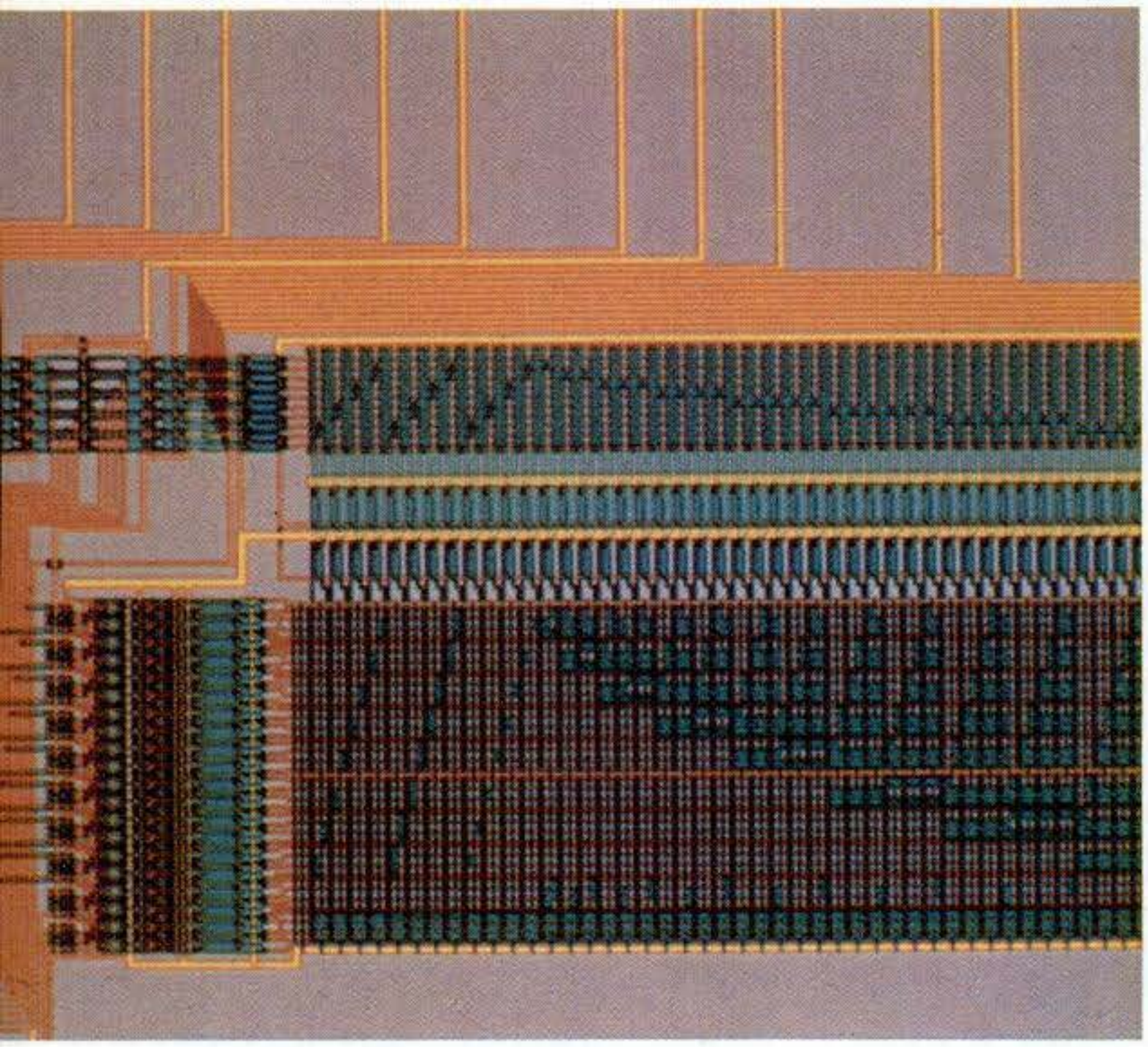

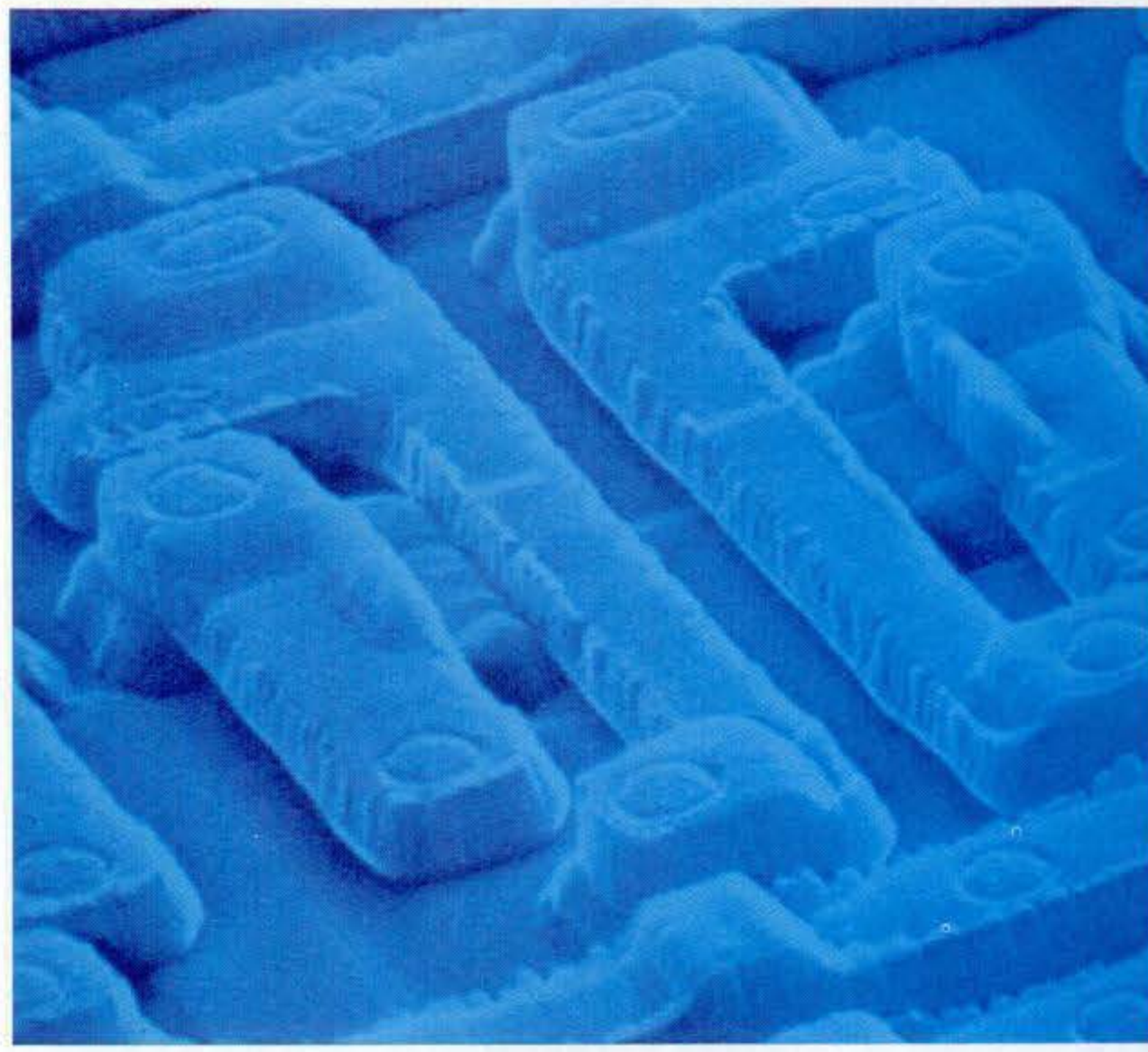

Going deeper into the microcosm, from left to right: A conventional lens yields a 5× magnification of a semiconductor chip, revealing enough detail for an expert to tell whether it is a memory or logic device and to guess how many circuits it contains. A scanning electron microscope shows half-micron lines at a magnification of 300,000×. They are too small to appear in an optical microscope. The next image, made with a scanning tunneling microscope, shows atomic-scale features of a thermally roughened surface. At a magnification of 3,000,000×, the large features are about 10 atoms high. In the last picture, also made with an STM, the cleaved surface of silicon crystal is magnified 24,000,000×, resolving the position of individual atoms.

tors, electrons will tunnel from one to the other, even though the voltage is much lower than classical physics would require.

The STM makes use of this principle in an ingenious way that provides an elegantly simple instrument. It operates something like a phonograph stylus tracking a record groove; its co-inventor Gerd Binnig has compared it to "a rusty nail that you scratch along some surface."

The "rusty nail" is actually a sharp needle, usually made from tungsten, whose tip is either ground or etched until it is preferably just one atom wide. (One physicist says that a few years ago "people working with STMs would sit around swapping tip recipes like chefs at a food convention.")

When this tip is lowered to within billionths of an inch of the surface to be imaged, and a small voltage is applied, electrons tunnel between the tip and the surface, creating a measurable current. If the minute distance between the tip and the surface is constantly adjusted so that this current remains constant, the tip will precisely trace out the hills and valleys conforming to the actual position of atoms on the surface, one line at a time. Repeated side-by-side scans build up a minutely detailed picture of the atomic landscape. The STM can sense differences in vertical height of only 0.01 angstrom.

This remarkable precision stems from a unique property of the tunneling current. It varies exponentially with the distance between the tip and the surface: The smaller the distance, the greater the current.

"A change of only one angstrom changes the current tenfold, so changing the distance by the diameter of a single three-angstrom atom means you change the current by a factor of a thousand," says Heinrich Rohrer in his office at IBM Zürich Research Laboratory. "It is this exquisite sensitivity that gives you atomic resolution."

The IBM facility is in the affluent little village of Rüchlikon, whose terraced hills overlook Lake Zurich, about a half-hour's drive outside Zurich itself. It consists of a cluster of antiseptically neat white buildings threaded with manicured lawns and pools, in which giant goldfish swim leisurely.

There is nothing leisurely about Rohrer. A burly 55-year-old with neatly trimmed gray hair and beard, his casual dress and relaxed sprawl conceal the driving curiosity that led him and his colleagues to the invention of the STM. For, as he says in heavily accented English, "We didn't start out trying to make a microscope at all. And when we did get the idea and told people at the lab what we wanted to do, they said 'You are totally crazy—but if it works, you'll get the Nobel.'

"Maybe we were lucky," says Rohrer, "in having in common a training in superconductivity," a field that their joint Nobel acceptance speech says "radiates beauty and elegance. For scanning tunneling microscopy, we brought along some experience in tunneling and angstroms, but none in microscopy or surface science. This probably gave us the courage and lightheartedness to start something which should 'not have worked in principle,' as we were so often told."

Rohrer's Ph.D. research had involved measuring small length

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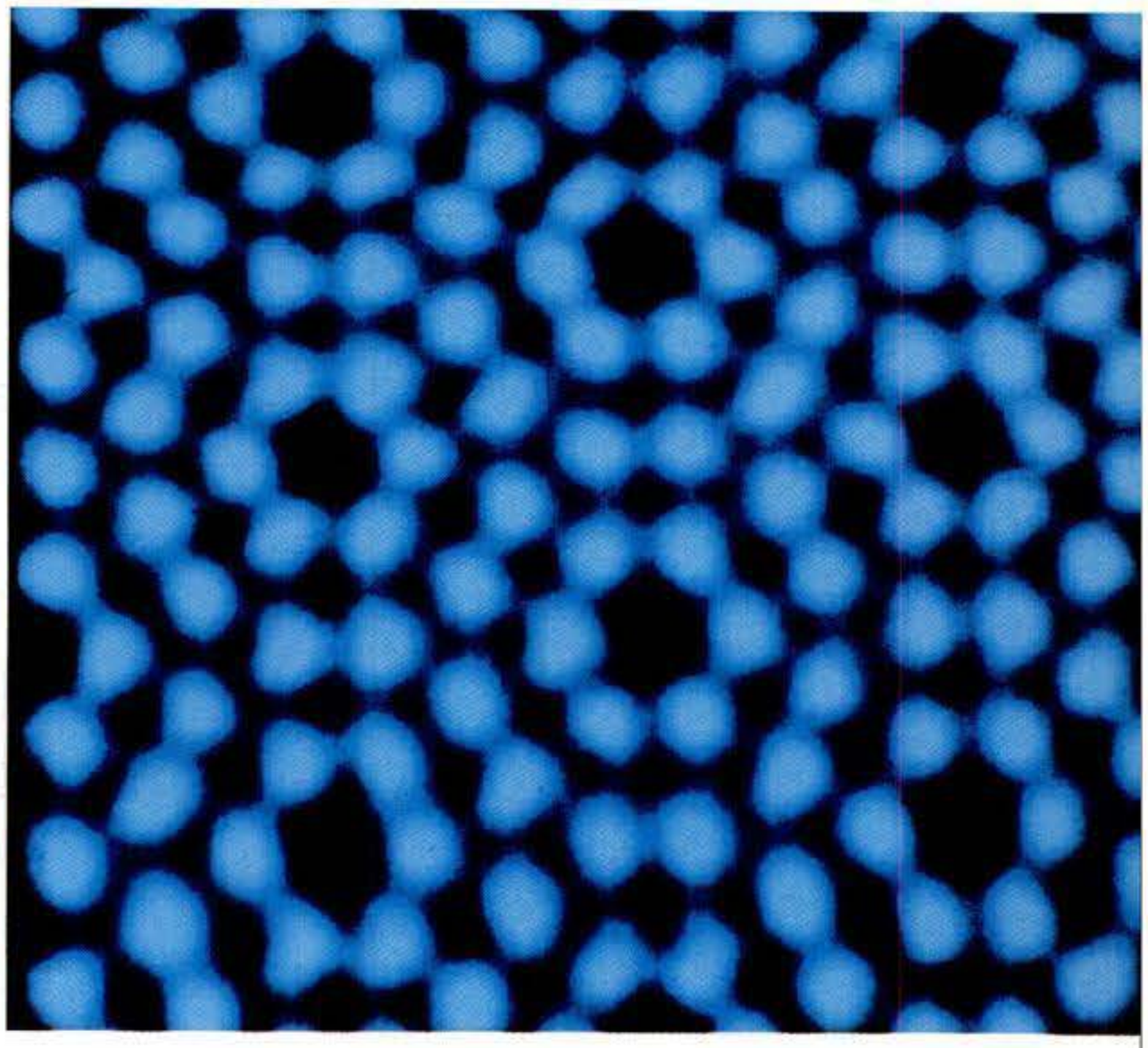

changes in superconductors; "that's where I lost all respect for angstroms," he says. He then spent years studying various kinds of electrical, magnetic, and mechanical phenomena in a variety of materials at IBM in Rüschlikon, starting in 1963.

"After much time spent in the areas of phase transitions, critical phenomena, and magnetic fields, I began to feel around the mid-1970s that it was time for a change. It gradually occurred to me that it would be interesting to look at the electrical and mechanical layers of very thin oxides. We had a Josephson project going on at the lab [i.e., work on the Josephson junction, a proposed—and abandoned—superfast computer chip that relies on tunneling at cryogenic temperatures]. The one thing they couldn't handle was the tolerances of the oxide layers. They couldn't get them accurate enough to regulate predictably the amount of tunneling needed for reasonable logic circuits. The tolerances are so stringent because of the exponential dependence of the tunneling current on the thickness of the layer. I thought it would be interesting to investigate the growth and electrical properties of these thin insulating layers on a very local scale. Essentially, what I wanted to do was spectroscopy on an area less than one hundred angstroms in diameter."

"You are totally crazy, but if it works, you'll get the Nobel"

To help with this new project, Rohrer sought a research staff assistant. "I lectured at various schools, looking for a likely candidate. Then Alex Müller [another IBM Nobel laureate, for his work on high-temperature superconductors] came to me and said, 'I have found someone extraordinary for you.' That was Gerd Binnig, then a graduate student from Frankfurt.

"It was clear," says Rohrer, "that we needed some technique to visualize inhomogeneities probably on a much smaller scale than microns—we didn't know how small. But none of the things we looked at was in the right ballpark. They would have given us a resolution of a couple of hundred angstroms up to a thousand; that wouldn't have contributed to solving the problem.

"But it seemed natural that as long as we were looking at electrical properties, we should be able to use the tunneling effect. You make a sharp point, and then try tunneling through a vacuum where you don't have to worry about the material properties of the barrier. That was very appealing. We thought we could make tips that would give us a resolution of about fifty angstroms—not tremendous from a structural point of view, but entirely new for looking at an electrical property. It seemed worth pursuing, so we started developing the technique in late '78."

To go from that point to the next stage took a leap of faith. Within a few weeks the two physicists realized that if the tip's position could be controlled accurately and scanned over the face of a surface, they would have not only a local spectroscopic probe, but an imager that could deliver a detailed atomic map—a microscope. Despite the doubts of some of their colleagues, in mid-1979 they submitted their first patent disclosure on a scanning tunneling microscope.

The next few years Rohrer and Binnig spent solving, with the help of Rüschlikon colleagues Christoph Gerber and Edmund Weibel, a variety of technical problems. Isolating the instrument from external vibration was one. The first-generation STM used the levitation effect of superconductors, but that cumbersome approach was replaced by damped springs, air tables, and rubber mounts in later-generation instruments. One of them is so small it can be held in the palm of the hand, and has been dubbed "the pocket microscope."

Another critical problem was controlling the position of the tip along all three axes on a fine scale. The ultra-simple method chosen was to suspend the tip from an inverted tripod, each of whose legs is perpendicular to the others. Each leg incorporates a piezoelectric material such as barium titanate. Such ceramics have the property of expanding or contracting slightly when a voltage is applied

Continued

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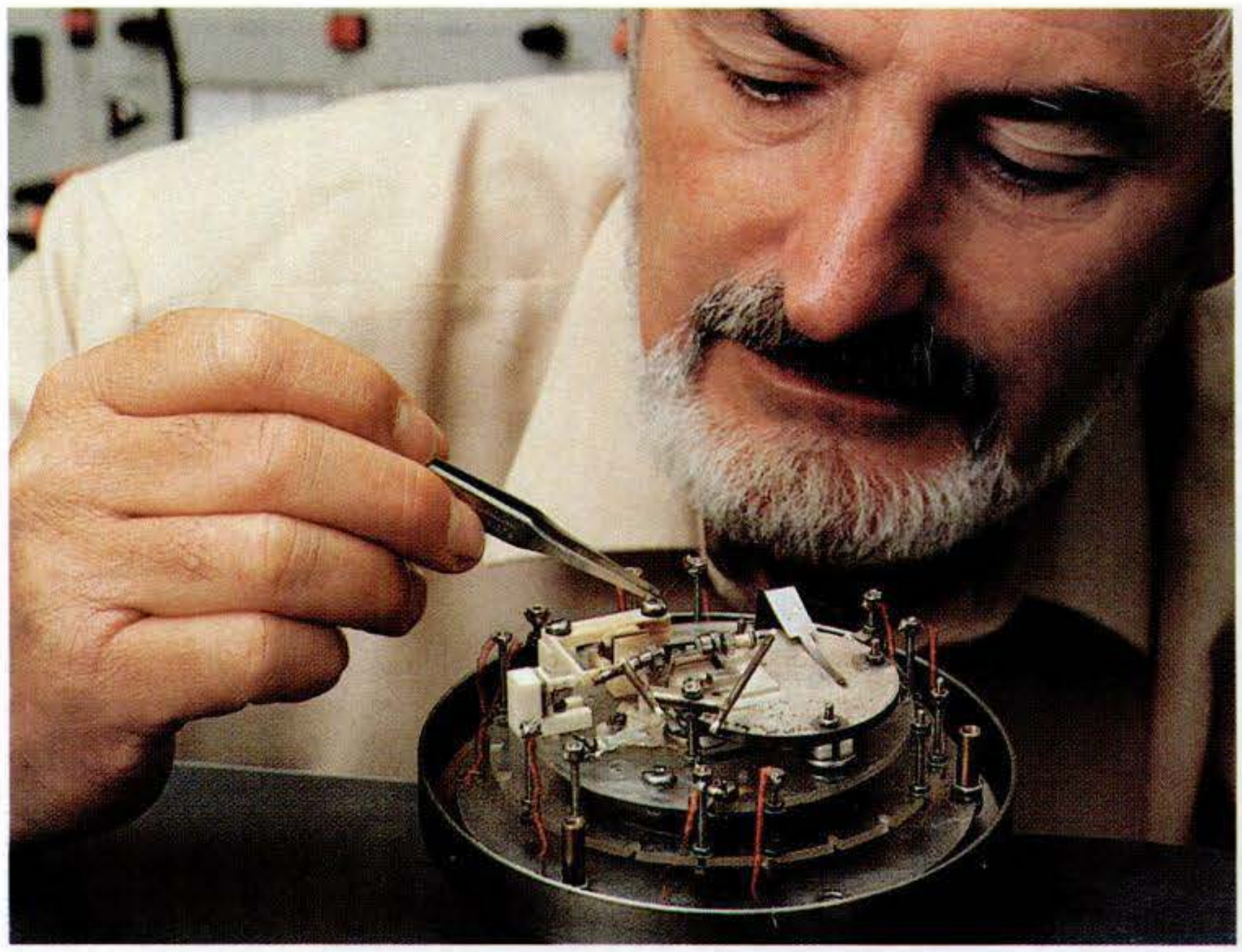
to them. Rohrer and Binnig found they could calibrate such a device so that they could move an STM tip by a fraction of an angstrom in any direction.

In 1981 the IBM team obtained its first real success, images that resolved steps only one atom high on the surface of a calcium-iridium-tin crystal. But the first attempt to publish failed when a journal referee found the paper "not interesting enough."

A major triumph came in 1982 when the team produced images of a silicon surface. These elucidated for the first time the intriguing organization of the so-called 7×7 unit cell of the silicon crystal, a complex structure with 49 atoms.

"I could not stop looking at the images," said Binnig in accepting the Nobel. "It was like entering a new world. This appeared to me as the unsurpassable highlight of my scientific career."



STM applications

Since 1986 many STMs have been built. They are installed in at least 100 laboratories around the world and are now commercially available. Although investigators are using STMs to gain fundamental insights in physics, chemistry, and biology, the instruments have become invaluable for developing applications in everything from computer technology to metallurgy to medicine.

In 1988, for example, a team headed by Joseph Zasadzinski of the University of California, Santa Barbara, used an STM to make an image of the wavy surface of a biological membrane made up of a phospholipid molecule known as DMPC. It is one of the surfactants that coat the human lung; the scientists believe the "ripple phase" they captured allows the lungs to expand with each breath, and that some premature infants with breathing problems actually lack the membrane.

At Ford Scientific Laboratories in Dearborn, Mich., Robert Jaklevic uses STM to understand the arrangement of atoms on metal surfaces, with a view toward developing better ways of bonding two sheets of metal together, improving the performance of paint and other coatings, producing more-effective catalysts for the control of tailpipe emissions, and developing better adhesives.

Using STMs designed and built at UCSB, scientists have even been able to see carbon atoms on an electrode before and after it was plated with silver—while the electrode was immersed in electroplating solution. The details gained about what is going on during an electrochemical process could help in the war on corrosion.

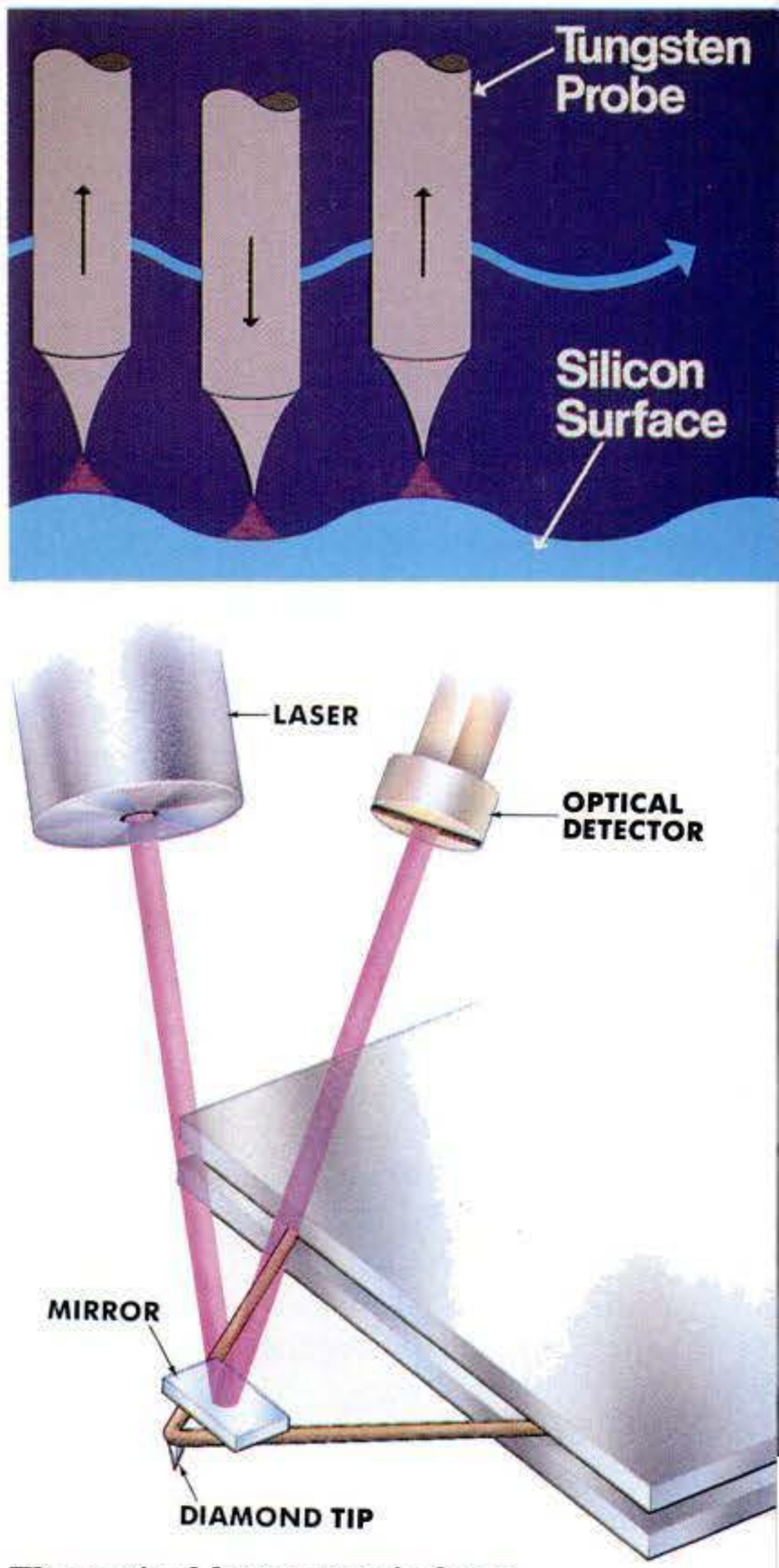
Last fall Praveen Chaudhari, IBM Research Division vice president, science, summed up this way: "The STM started as an attempt to solve a problem in technology, became a science, blossomed, and now has many technological applications."

What the STM cannot do, however, is work well with nonconducting materials, because it depends on electron tunneling. Biological specimens under the STM must therefore get a metallic coating, or be replaced by exact replicas made with the technique called freeze fracturing (as was the membrane discussed above). Similar restrictions apply to any nonconductor.

Enter the AFM—the atomic force microscope. It was invented by IBM Zürich's Binnig and Gerber in collaboration with physicist Calvin Quate of Stanford University's E. L. Gintzon Laboratory.

The AFM, like the STM, scans a surface by moving a tip along it one straight line at a time. But it is in actual contact with the material, and senses the minute forces that exist between atoms. By analogy, it is like someone dragging a finger along a brick wall to sense its texture.

The original AFM uses a diamond tip mounted on a tiny gold-foil cantilever spring that can ride up and down. A small force is applied to the tip, just enough to keep it in contact with the surface, but not enough to cause damage. A typical force used is one-hundred-millionth of a Newton—about a millionth of a gram, or a million times smaller than a typical tracking force for a diamond phono stylus. And it happens to be about a million times smaller than the force your finger tip



The optical-lever atomic force microscope was invented independently by groups at IBM and UCSB. A laser beam bounces off a mirror mounted on the diamond tip and is picked up by an optical detector, which senses minute changes in position.

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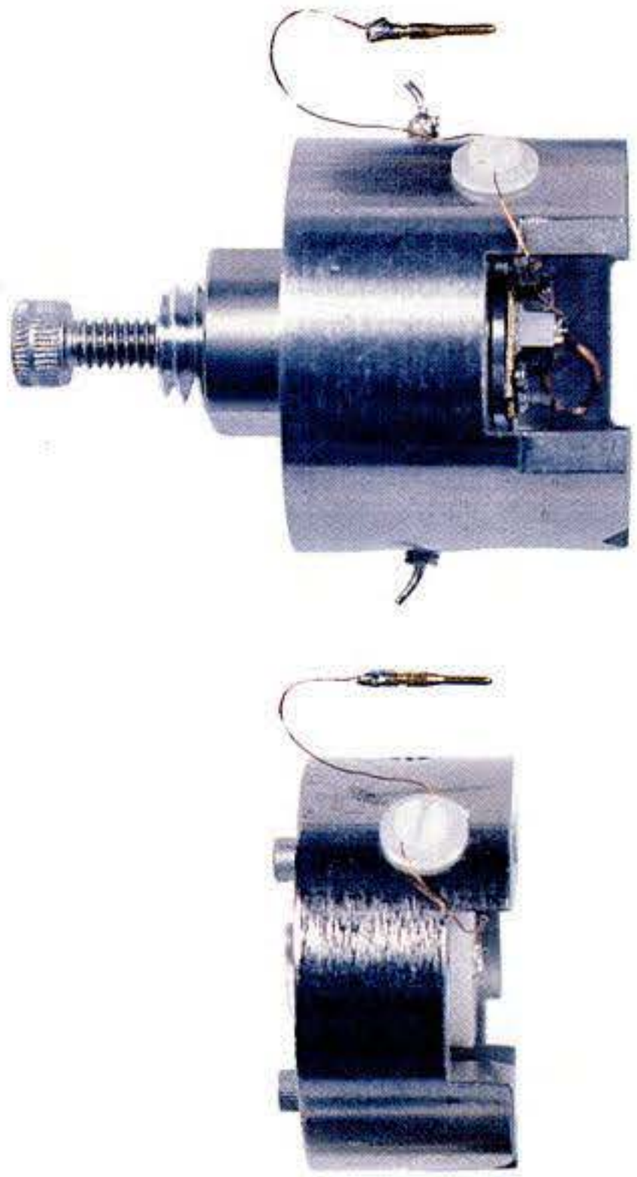
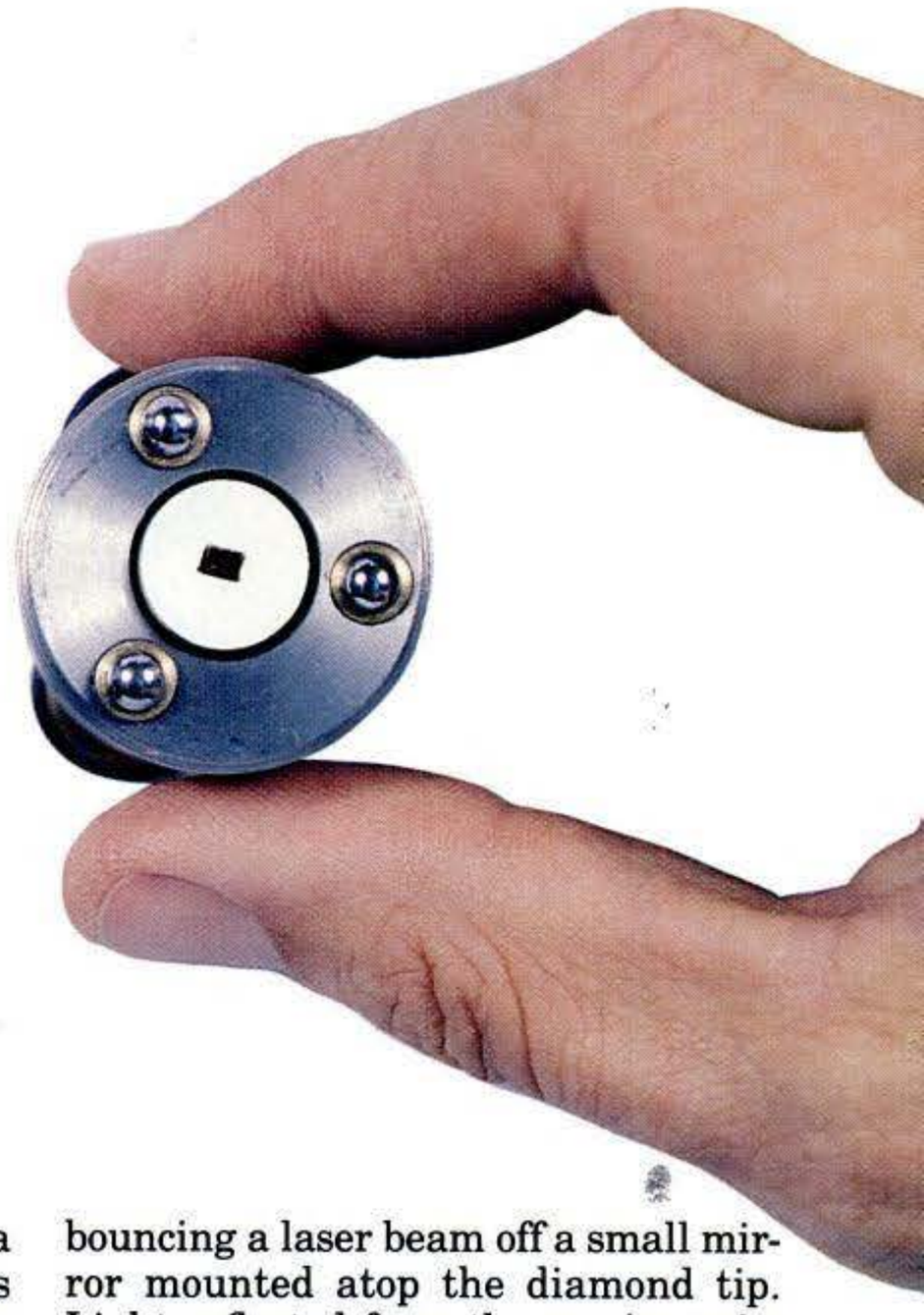
Opposite page: Heinrich "Heini" Rohrer tweaks one of the early models of the scanning tunneling microscope at IBM Zürich Research Laboratory. Below, a schematic representation of the STM's principle—a tungsten probe with a sharp tip is moved along a surface so that the electron tunneling current remains constant. Result: The tip traces the hills and valleys of the atomic landscape. This page: Paul Hansma of UCSB holds the separable pieces of a small and portable combination STM/AFM. The base (in his hand) holds a three-way scanner on which is mounted the sample (the small black rectangle). The AFM head (top left) or the STM head (bottom left) rests on top of the three screws in the base.





must apply for its nerves to feel a surface.

The interatomic forces sensed at the end of the tip cause the cantilever spring to deflect slightly, corresponding to the atomic structure.

Professor of physics Paul Hansma, in the advance guard of AFM work, explains the technique in his UCSB lab near the edge of the Pacific. "When the tip goes over a bump it deflects up, and when it goes over a valley, it deflects down. So we don't need a conducting surface... we're just feeling it. But now we need a way to measure these deflections."

The answer the inventors of the AFM provided has the simplicity of genius: They sandwiched the diamond tip and its gold spring between the sample and an STM tip.

"We literally tunnel to the back of the metal cantilever," Hansma explains. "So as it rides across the sample, if it goes up, it narrows the gap between it and the tunneling tip, and we see more tunneling current. Down, and we see less current. We kind of fake the electronics—the instrument thinks it's doing tunneling, but it's actually measuring the deflections." The result was to endow the AFM with atomic resolution. Positioning the tip, as in the STM, is accomplished with piezoelectric manipulators.

How does one get a diamond tip so sharp that its tip is—ideally—just one atom wide? The approach, says UCSB's Scot Gould, is not subtle:

"In fact, it's not even very scientific. Paul goes down to a pawn broker and buys some cheap diamonds for five or six bucks. We put them between two steel plates and smash them, and get all these little shards. Then, under a microscope, you find one that looks good and pick it up with a little piece of string, to which the splinter clings electrostatically. If the shard is sharp enough, it will come to a point that is only one atom wide. If we get pictures without good resolution, we know the tip had too many atoms at its end."

All of the microscopes, including STMs, that have been built in the UCSB lab were first modeled in wood to show the basic operating principles. Their craftsman is Barney Drake, a member of the team, who works from crude sketches. And they are all arrayed along a table in what Hansma calls "our museum." They resemble what one imagines Leonardo da Vinci's workshops might have turned out in similar circumstances.

No more tunneling

Ironically, much of the equipment here is plastered with little stickers reading "Electron Tunneling Group."

"It's kind of a joke in our lab," says Hansma, "because for the first time in my career I'm not involved with tunneling, and none of the AFMs we are now using has a tunneling head. We've abandoned that technique for something new—measuring the deflection with laser light.

"The new instrument is called the optical-lever AFM, and was invented for us by Sam Alexander here—we didn't know that people at IBM Research in Yorktown Heights [N.Y.] had gotten the same idea independently before we did. It works much better than the tunneling AFM, so we've abandoned electron tunneling."

The optical-lever AFM works by bouncing a laser beam off a small mirror mounted atop the diamond tip. Light reflected from the moving mirror is detected by a position sensor; minute deflections are amplified, or "levered," by the geometry of the system so that the unit can detect a vertical change in a surface of only 0.1 angstrom.

The future of both these remarkable scanning probes—STM and AFM—seems virtually unlimited. In 1986 Calvin Quate wrote about the STM in *Physics Today*:

"When we review the history of the scanning electron microscope we learn that it evolved from an imaging device to a system for writing the fine lines in integrated circuits. Some of us believe that the scanning tunneling microscope will evolve in the same way... that one day [it] will be used to write and read patterns of molecular size."

Moreover, Quate wrote, "One day we hope to reach the point where it is possible to manipulate individual atoms or molecules with the tip."

In the short time since that prediction, the first steps to what could be called atomic-scale engineering have been taken. One group has placed a single atom onto a germanium surface; another pinned an organic molecule to a site on a graphite surface.

In a prophetic paper written in 1961, the late great physicist Richard Feynman foresaw what such a technology could mean. If we can some day arrange atoms and molecules to our plan, he wrote, "we will get an enormously greater range of properties that substances can have, and of different things that we can do." PS

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SHOW

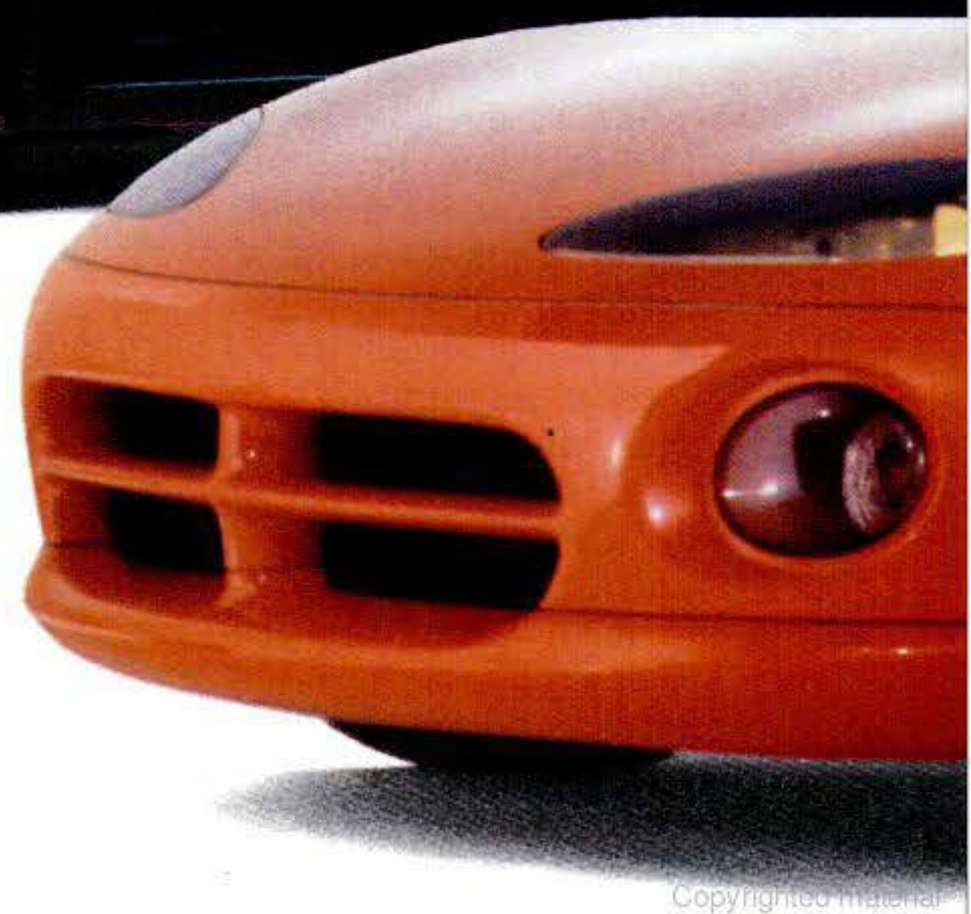
DETROIT'S HIGH-TECH CARS FOR THE '90s

By DAN McCOSH

FORD SPLASH

MERCURY CONCEPT 50

PLYMOUTH SPEEDSTER



From the sleek, hot California Camaro sport coupe to the technology-ridden Chrysler Millenium to the fun-driving Ford Splash, Detroit displays a pot-pourri of eye-popping designs for the future at its annual auto show.

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STOPPERS

CHEVROLET XT-2

If the array of concept vehicles unveiled at the first North American International Auto Show in Detroit is any indication, the future of the automobile just might not be a car.

Manufacturers showed some 25 concept vehicles at the recently expanded show, but what made this exhibition distinctive was the absence of the squashed-bubble streamliners that never seem to make it to production. Instead, the concentration was on recreational and multipurpose vehicles that could function in several worlds.

Ford demonstrated a futuristic four-wheel-drive off-road vehicle that had many of the features of high-performance sports cars. The Ford Splash, based on available front-drive components from the Ford Festiva, had a dune-buggy-like presence accentuated by removable panels in the roof. Created to celebrate the Mercury division's 50th anniversary, the sleek V6-powered Tempo-sized all-wheel-drive Concept 50 hatchback appears to be producible.

Plymouth once again adapted a motorcycle to the car business with its Speedster—a rear-engine rear-drive two-seater. It's the second such effort from Chrysler in recent years, evidence that the concept is gaining some acceptance for production.

But the hottest pure sports car at the show was the Dodge Viper. It was inspired by Carroll Shelby and is strongly reminiscent of his mid-1960s Shelby Cobra. The Viper packs a V10 power plant, currently being developed as a truck engine by

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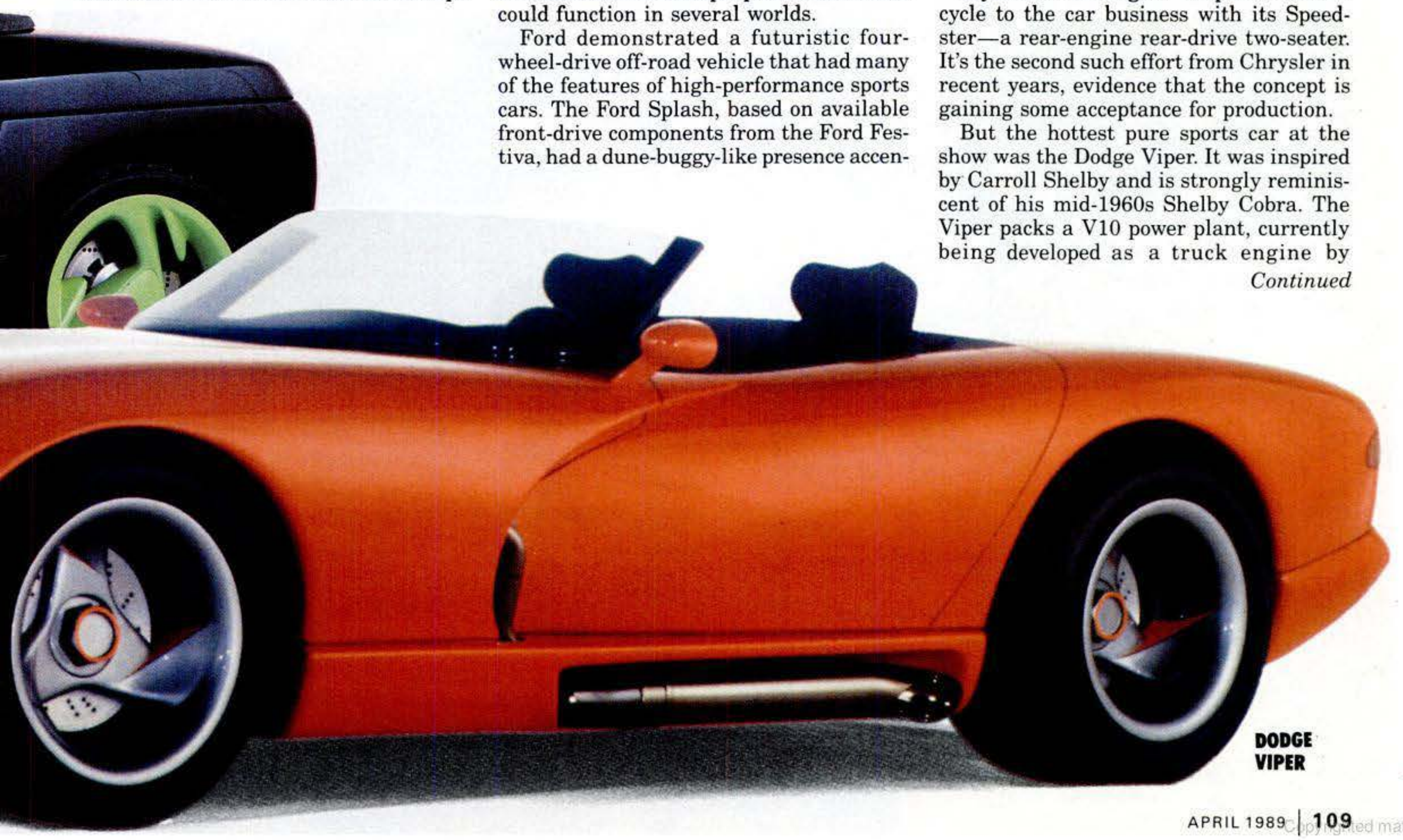

DODGE VIPER

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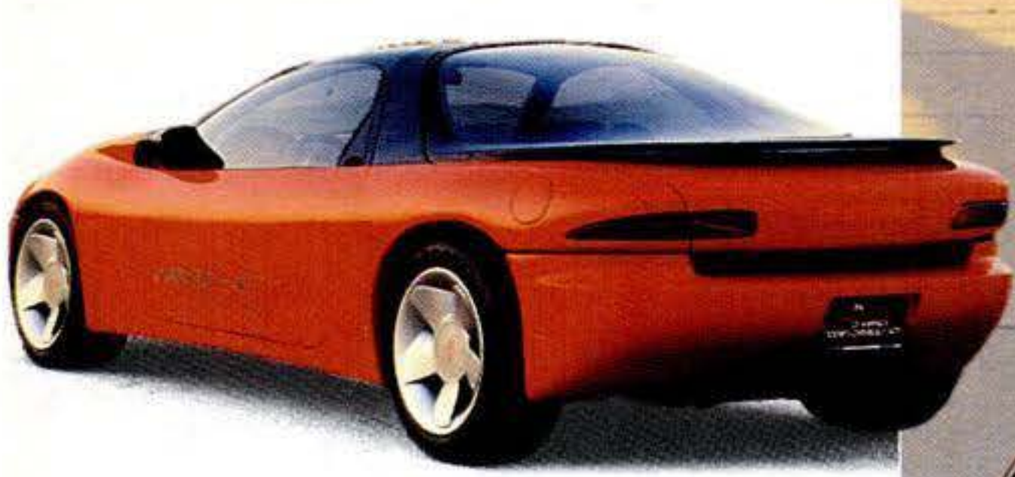

CHEVROLET CALIFORNIA IROC-Z CAMARO

Chrysler and modified for use in the Viper.

The Viper's V10 shared the big-engine spotlight with a new Lotus-engineered V12, which powers the two-seat ultra-luxury Cadillac Solitaire.

Even a pickup truck took a turn in the high-performance spotlight with the Chevrolet PPG XT-2 Pace Truck, with an engine based on the IROC-Z Camaro's 360-horsepower V6 and a suspension derived from the Corvette.

A Camaro also provided the underpinnings for the California IROC-Z Camaro, with gullwing doors it is another trial balloon General Motors is flying to test the future of its rear-drive F-bodies. The concept Camaro's styling reportedly is close to the next generation of production cars.

GM threw another ringer into the Detroit show with its Oldsmobile Silhouette, a plastic-body space-frame people mover intended to compete in the hot minivan market. In fact, the futuristic Silhouette is going into production this spring, along with Pontiac's Tran Sport and Chevrolet's All Purpose Vehicle.

Likewise, there are hints that the Olds Aerotech II, which is being considered for production, is powered by a supercharged version of the Quad 4 engine.

Finally comes Chrysler's Millenium, strongly reminiscent of the Portofino show car demonstrated last year, but this time emerging as a test bed of safety devices. It features rain-activated windshield wipers, traction control, and even a microchip aimed at sobriety: An interlock prevents drunk drivers from starting it up. PS

OLDSMOBILE SILHOUETTE

CHRYSLER MILLENIUM

OLDSMOBILE AEROTECH II

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The quiet diesel

By DAVID SCOTT

Diesels are noisy, sluggish, and smelly—right?

Yes, but a team of Austrian engineers has been working hard to overcome these shortcomings. The result is a startling new diesel design from Steyr-Daimler-Puch that's only guilty of the third offense. It's intended to give the buyers of refined high-performance cars a fuel-efficient alternative to gasoline engines.

"We've cut mechanical noise dramatically by acoustic encapsulation," explained Dr. Peter Egger, marketing engineer at the Steyr plant. "Packaging the entire engine in sound-deadening metal is combined with an advanced fuel-injection and combustion system that makes it much quieter than any ordinary diesel." It's a compression ignition engine that doesn't sound like one, he claims, because it virtually eliminates the familiar clatter of diesel knock.

"The injection system also gives snappier performance through improved combustion, which in turn reduces exhaust emissions," Egger told me. "And fuel consumption is fifteen percent below that of most existing diesels, or about forty percent less than a modern gasoline engine of similar power."

To achieve the acoustic improvements, Steyr came up with an unusual monobloc cast-iron cylinder-and-head design that supports the main bear-

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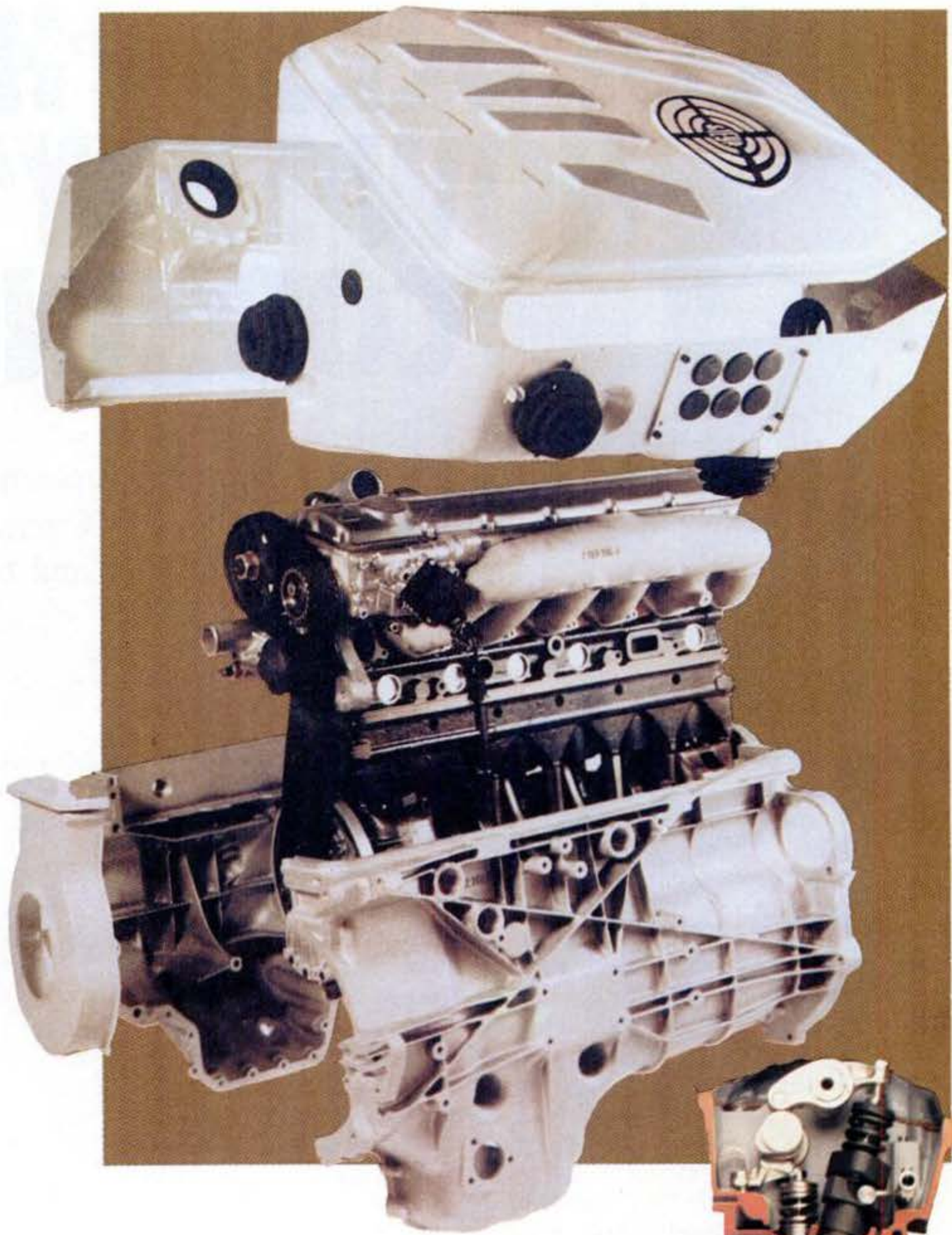

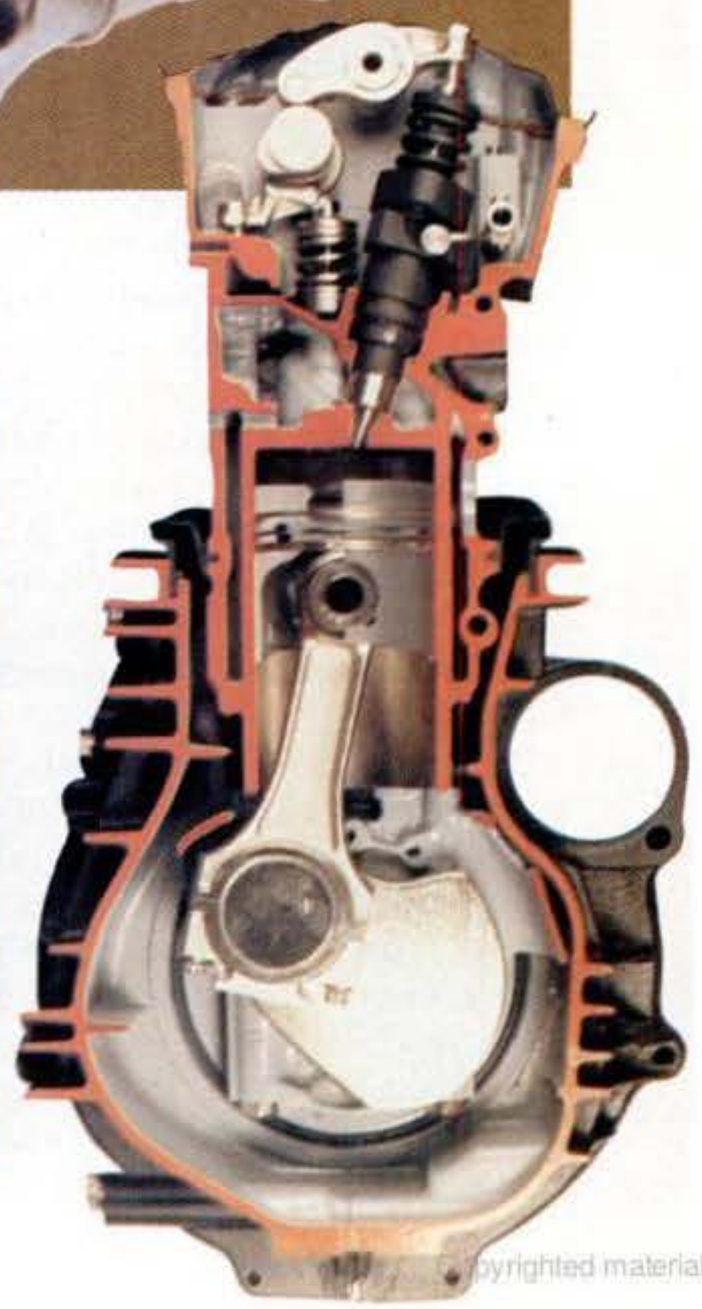

Exploded view of six-cylinder turbocharged diesel engine (top) shows the iron cylinder block and separate cast-aluminum crankcase, which serves both as the oil sump and as a noise barrier. The cylinder head is enclosed in a sound-deadening shroud made from sheet-metal pressings. A cross section of the Steyr diesel (far right) shows its monobloc construction—the nonremovable cylinder head is cast in one piece along with the cylinder block. Driven by an extra lobe on the overhead camshaft, the combination fuel pump and fuel-injector unit located at each cylinder delivers fuel in two stages to combat diesel knock. Dropped into the engine bay of a Pontiac Firebird (right), Steyr's encapsulated diesel presents a neat package.

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CORDLESS PHONES—NOW THEY'RE COOKIN'

Cordless phones, once a novelty, are now replacing conventional telephones in the home. To do it meant new FCC regulations and entirely new designs to increase security and battery life.

By MARTY LEVINE
Photo by John B. Carnett

The phone call is crisp and clear, like thousands of others I've made in the past. The conversation I'm having is rambling—but so am I as I roam from room to room. How? I'm using a cordless phone that frees me from the usual telephone cord that ties me to a five-foot circle. Think that's no big deal? Think again.

There's been a quiet rebirth of cordless phones. They're no longer novelties but are convenient communications devices that rival the models that have cords. To do that, engineers solved some problems plaguing earlier designs: how to make cordless phones sound better, be more reliable, operate longer on a battery charge, and be free of "phone pirates"—people who use *your* phone line to place *their* long-distance calls. It took more than new electronics. It also took intervention by the Federal Communications Commission.

The result is a cordless phone that's now taken seriously. "People are putting it on the coffee table in the living room and using it as a regular phone," says Ken Leland, a product-development engineer at AT&T.

To find out how cordless phones have been changed, I spoke to Leland and other experts at several major cordless-phone manufacturers, as well as officials at the FCC. What they had to say would surprise anyone who hasn't handled any of the new models.

Energize them

Early cordless phones began with a handicap that instantly harnessed them with a poor reputation: The phones had to use one of only five frequencies that were just above the upper range of the AM-radio spectrum. The channels were crowded, noisy, and subject to a bevy of electrical interference. "The phones had been operating at 1.6 to 2 megahertz," says Julius Knapp, chief of the FCC's Frequency Allocations Branch. "There was a lot of interference."

But in July 1986 the FCC opened several more stretches of spectrum, including 10 channels at 46 and 49 megahertz for cordless-telephone use. That doubled the number of available channels, which eased crowding and, according to Knapp, allowed more reliable communications. "There's less noise at the higher frequency."

With those changes cordless makers were free to create a competitive phone—similar in characteristics to all others—minus a cord. For AT&T's Leland the differences in cordless development started the day he first walked into the company's product-development lab. "I was surprised to see a three-hundred-page manual detailing antenna and other component parameters," he says. AT&T, along with most other cordless manufacturers, has upgraded the voice coils, speakers, and other components that go into its cordless phone.

Even with excellent voice quality, cordless phones wouldn't be elbowing aside conventional phones if manufacturers hadn't solved another thorny problem: battery life.

Because of the extended and varied use of the new portables, battery life—the useful time between charges—becomes extremely important. (The battery is recharged only when the handset is returned to its charging base.) One way to increase the battery life is to increase the size of the battery. The more power it contains, the longer it takes to discharge. Another way is to decrease the amount of current needed by the phone. The lower the current drain, the lower the discharge rate. Most makers use both techniques to some degree.

For example, AT&T changed from a button-type battery to a taller, cylindrical shape for a quicker and deeper charging time. "With the new battery design," explains Leland, "we're able to use a higher charge current."

Panasonic has also worked on its battery design, with similar results. "We're getting up to three days between charges," says Mike Troetti, Panasonic

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Reach out and touch someone—but from a distance—with one of the new high-quality cordless phones.

national sales manager. "We were getting only eight hours before."

All companies are using low-power-consuming components in their phones, but AT&T has devised a power-miser *circuit* too. Its trick: "The circuit actually turns off the phone," says Leland. While all portables consume energy because their receiver circuit must "listen" for an incoming call, the AT&T 5000 series cordless phone listens for only a millisecond. If nothing is received from the base unit, the phone switches off again. "It's off for well over ninety percent of the time," says Leland. Result: "We can get about a week of operation between charges."

Technical improvements help keep cordless phones working better, but not farther. The FCC has limited the transmitter output of both the phone and base, so the maximum range between the two is about 1,500 feet. However, in practice most phones fade out well short of that range. But at almost one-third of a mile, that should be a big enough range for most people.

Pirates and eavesdroppers

As a phone spends more time away from its charging base, the possibility of phone pirating increases. Anybody with a portable phone that comes within 1,500 feet of your charging base could become a phone pirate. How? He

[Continued on page 146]

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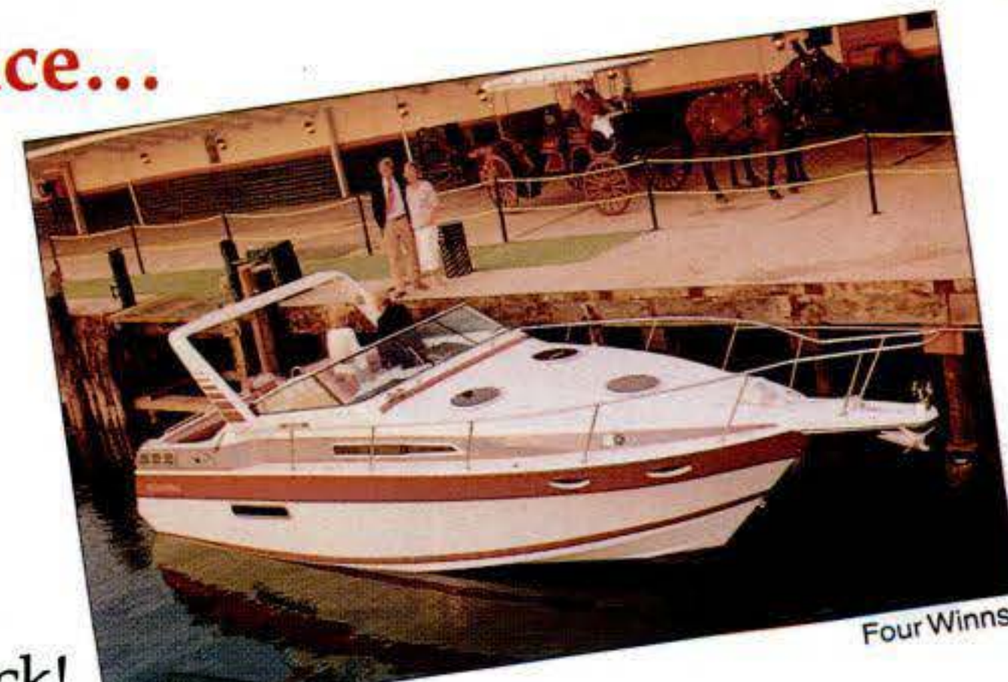
How to Talk to Nine Boat Companys With One Free Phone Call

Donzi

The Power of Choice...

Until recently, buying a boat and getting it to the water took a lot of commitment. Pick a boat brand. Pick a dealer. Pick an engine. Pick a trailer. Pick a finance company. Pick a marine insurer. Pick! Pick! Pick!... It was enough to turn a lot of people off. Now the OMC Boat Group, with a stable of nine of the finest names in boating and a network of more than 2100 marine dealers nationwide offering everything from aluminum fishing skiffs to luxurious, live-aboard, wide-body cruisers, has taken much of the hassle out of boat buying. Call us toll free, tell us the kind of boating you're interested in, and we'll direct you to one or more professional marine retailers in your area with a range of complete, water-ready models to fit your brand of water action.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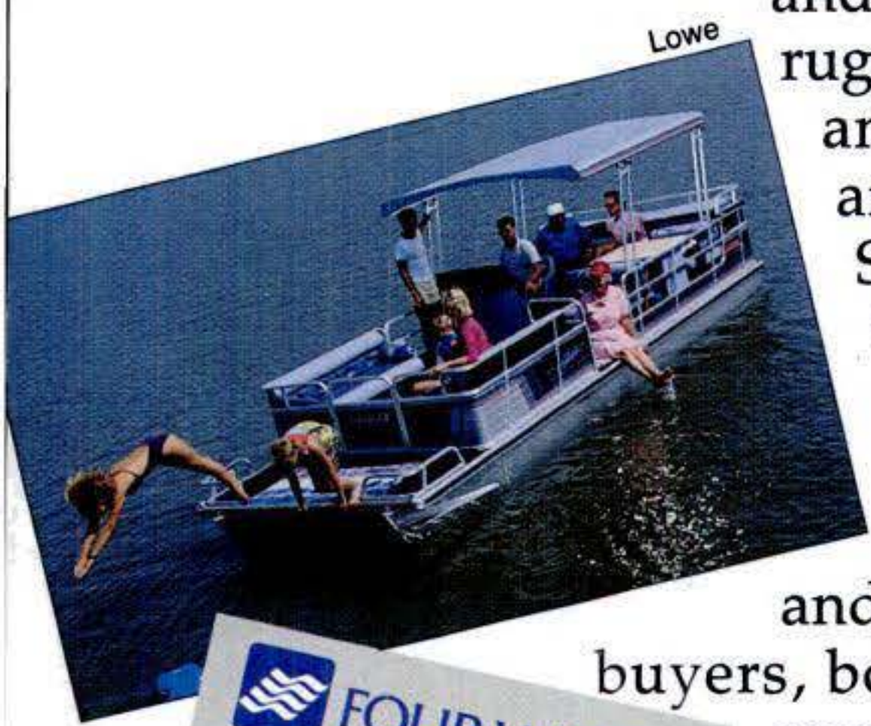
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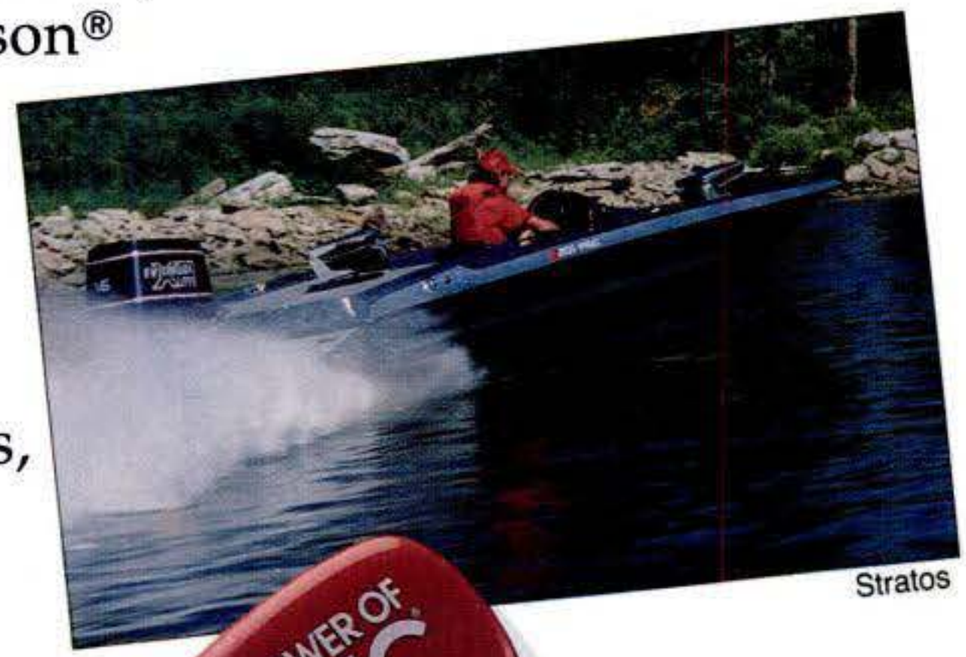
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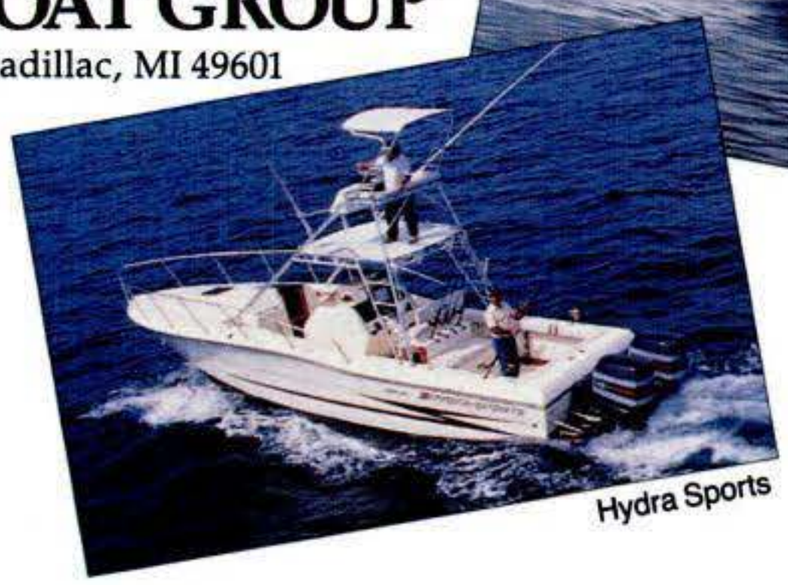
Hydra Sports

PORTS/SEASWIRL/JAVELIN/SEA NYMPH/DONZI

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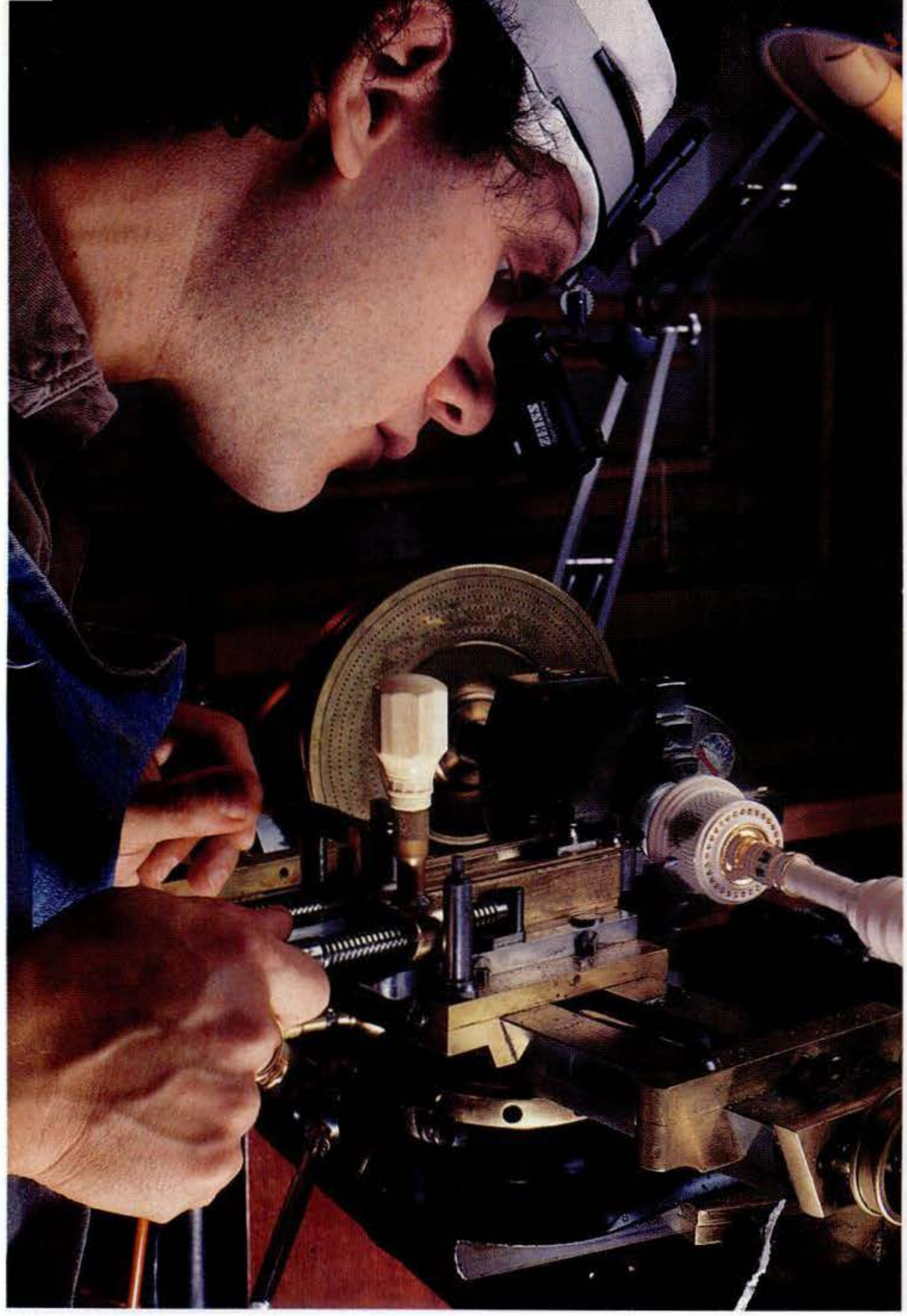

A tiny subculture of lathe craftsmen do what is called ornamental turning. The remarkable machines they use, called Holtzapffel lathes, date from the 19th century. Few exist today; those that do sell for astronomical prices. Now one enthusiast has overcome the problem: He's making modern renditions.

THE ULTIMATE LATHE

By P. D. UNGERER
Photos by John B. Carnett

It's been called the ultimate tool, a wondrous machine capable of producing exquisite objects as no other machine can.

In this age of technological marvels, it is startling to realize that it was invented in 1794 and last manufactured in 1914—although the Lawler Gear Corp. in Raytown, Mo., is now producing a modern version on a limited-edition basis.

It is the Holtzapffel (Hoe-saw-fel) ornamental turning lathe. It is to tools what the Lamborghini is to autos, what Fabergé is to jewelry.

Through a plethora of ingenious mechanical devices and hundreds of cutters, the Holtzapffel ornamental lathe allows practically any embellishment imaginable—in practically any plane—to be incised into a turned work while it is on the lathe. Highly orna-

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mented turned objects were created long before the Holtzapffel machine, but they were turned on a conventional lathe then removed from it, and the surface embellishment added by hand.

Founding father

John Jacob Holtzapffel, the lathe's inventor, was an engineering genius from Alsace who settled in London in 1792. Holtzapffel and his descendents produced these incredible machines throughout the 19th century. Other companies turned out similar lathes at the zenith of their popularity, but the Holtzapffels made more than all the others put together—maybe 5,000 in all. Today only a few are known to exist—estimates range from 300 to 500—and many are in museums. Very few are still used.

it," Brush reports. "He's an amazing mechanic." Brush owns the last and most complete Holtzapffel lathe made, as well as the earliest recorded. Parts of a fifth ornamental lathe, now undergoing painstaking restoration, lie on a tarp on the floor.

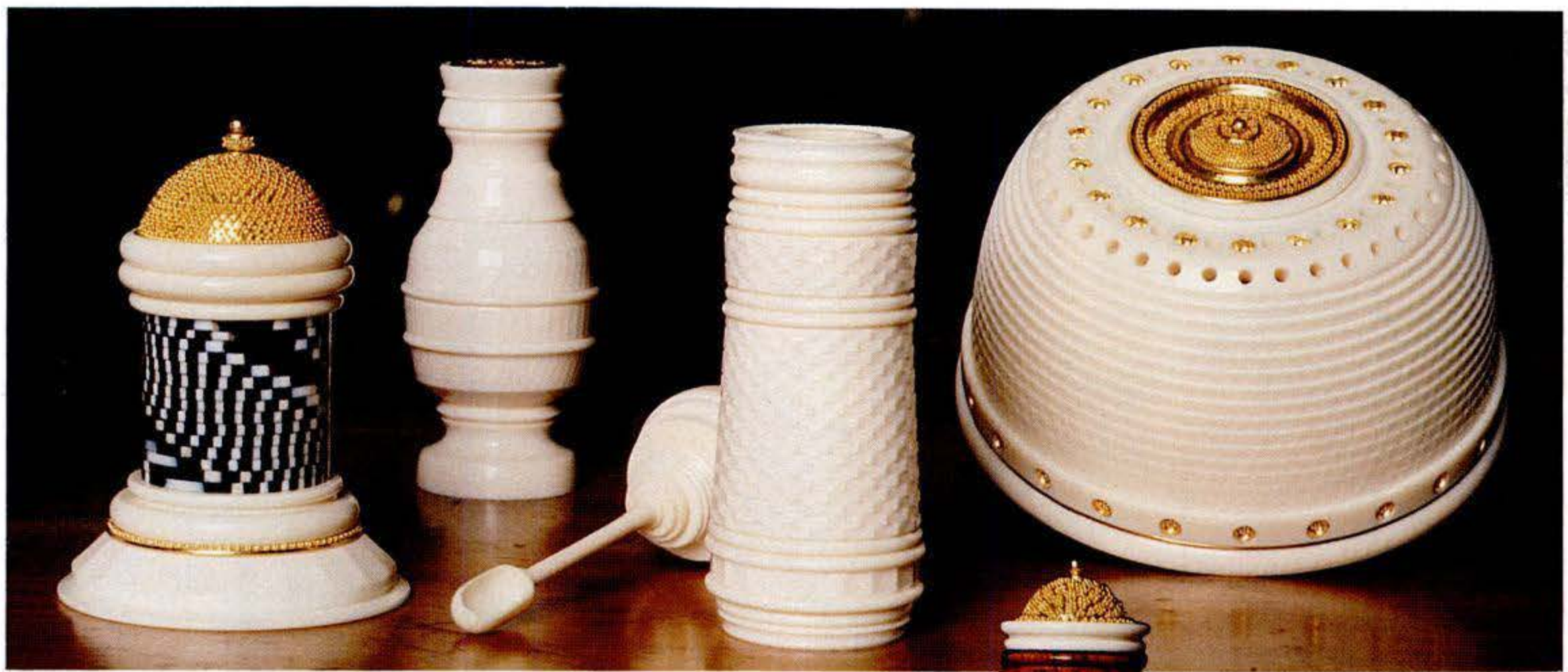
What spurs these collectors?

Says Hernandez: "I could spend the rest of my life working with the lathe every day. My children and their children and their children's children could do the same, and none of us would have to duplicate a design or decoration unless we chose to."

How is that possible?

"Because," Hernandez goes on, "the usual lathe, while one of man's oldest and most versatile tools, is limited. Material can only be shaped or decorated in the direction the material is rotat-

Artist Daniel Brush (opposite page) works in ivory. The exquisite pieces below were designed and made by him. Trim is 24-karat granulated gold. A purist, Brush has not motorized his ornamental lathes. He runs them by treadle for better control. (The geometric pattern above and those on the following pages are from a book written by Holtzapffel, the lathe's inventor.)



One that is, Holtzapffel lathe No. 2325, manufactured in 1877, is owned by Ed Hernandez of New Orleans, La. He searched for years for a machine. He finally found one in London and outbid 75 people at an auction.

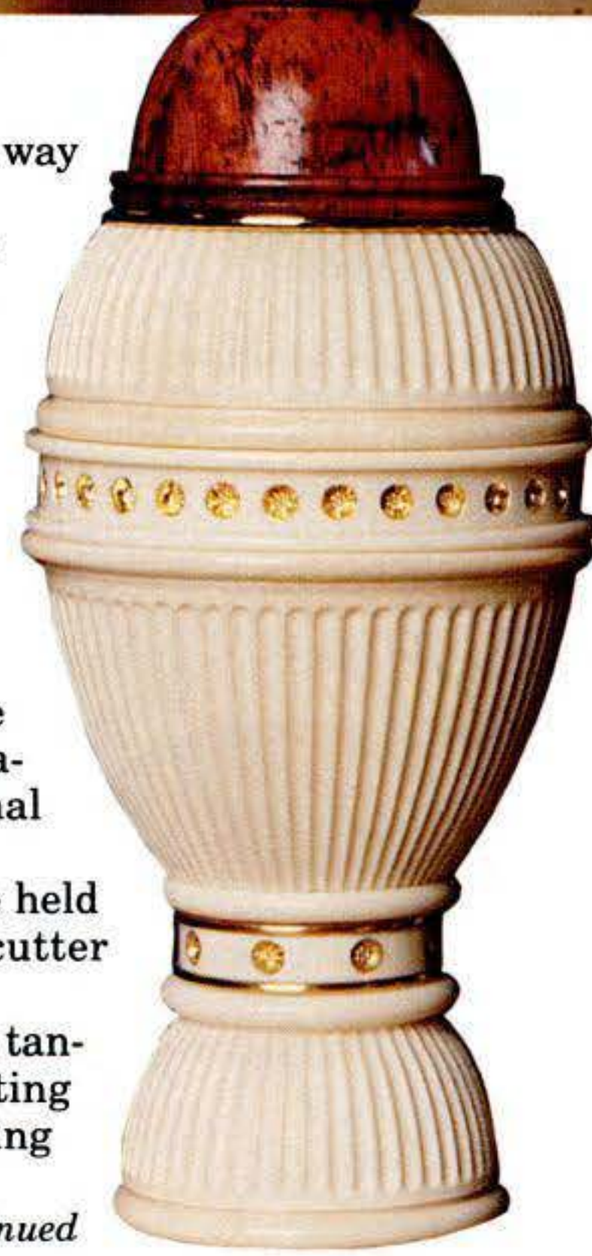
Frank Knox in New York City owns No. 2023, made in 1853. It was located for him by an English member of the Society of Ornamental Turners. The lathe arrived at Knox's midtown Manhattan studio in 1963 in a crate that weighed 3,600 pounds. Today the brass, steel, and mahogany marvel shares his 12-by-18-foot studio with a Shopsmith and Knox's impressive collection of exotic hardwoods. At 86, Knox continues to pursue the lathe's limitless possibilities.

Daniel Brush, a New York artist, has three Holtzapffel lathes and a similar Evans lathe operating in his Manhattan loft. One belongs to his six-year-old son. "He is beginning to treadle on

ing. The Holtzapffel goes way beyond that."

The machine's versatility comes from the brilliant way that Holtzapffel designed the headstock and the tool rest. Both—along with their various components—can be powered. Three basic modes of operation result:

- The work can revolve while the tool is held stationary, as in conventional wood turning.
- Or the work can be held stationary while the cutter revolves.
- Or both can move in tandem, as when you're cutting threads on a metal-turning lathe.



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"No single attachment converts an ordinary lathe to an ornamental lathe," writes Frank Knox in his book, *Ornamental Turnery*, published in 1986. "So it's difficult to discuss them in any sensible order of priority." He opts to explain the tool rest first.

While a conventional wood-turning lathe's tool rest is merely a platform on which to steady the hand-held cutting tool, an ornamental lathe has a slide rest similar to that of a metal lathe. A slide rest is a complex device that can move laterally along the ways of the lathe. It carries a tool holder that can move laterally along a lead screw, as on a thread-cutting metal lathe.

A Holtzapffel lathe comes with a set of 16 brass gears that, in various combinations, can connect the lead screw to the headstock spindle, thus moving the tool holder (and the cutter it holds) at a fixed rate relative to the rotation of the work turning in the spindle. With the work rotating and the tool traveling laterally, you can cut spirals, for example, along the length of your work. "It lets you cut threads to micro tolerances," Hernandez says: up to 40 threads per inch. Or you can carve a long, lazy spiral that makes one complete revolution over a distance of seven inches.

Frank Knox, at age 86, creates intricate pieces on his Holtzapffel lathe. The lathe's lead screw (see text) is in the foreground. The indexing plate (also in text) is the circular affair behind the headstock ringed with four rows of holes. At center right a belt (running from the overhead drive) wraps around the pulley of a cutting frame, activating the cutter.

Cutting tools

Frank Knox owns a three-drawer mahogany box made by John Jacob Holtzapffel himself. In the box are rows of bits and cutters—650 in every conceivable size and shape. When Knox's lathe and cutters arrived, his English colleague who had arranged

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the purchase sent a note with this advice: "Retire and teach your wife to sharpen the cutters." They must be kept razor sharp; you can't sand ornamental turnings.

Some of the bits revolve, like conventional drill bits, but they're shaped to create decorative elements—tiny pearls, for example, or stepped dimples. The cutters are like chisels. For many operations they are powered, and when used that way they may whirl in a circle around a fixed axis.

The cutter or bit is held in a cutting frame, which in turn, is held by the tool holder on the slide rest. Hernandez's machine came with 20 cutting frames.

Depending upon what cutting frame you use, the bits and cutters can be driven vertically, horizontally, or at any intermediate angle relative to the work.

Overhead drive

For operations that require the cutter to be powered, the power comes from a belt-and-pulley overhead-drive mechanism that Knox likens to a dentist's drill. A belt runs from the treadle and flywheel under the lathe (or from the motor added by most contemporary ornamental turners) to a cylinder on the overhead drive. From the cylinder a second belt drops down to wrap around pulleys on the cutting frames.

While the cutter is rotating, the work may be held stationary in the headstock. This is accomplished with the brass indexing plate: The headstock has a stepped pulley and on its face are rows of evenly spaced holes; these accept an index pin. When engaged, it holds the headstock, and thus the work, stationary. Moving the index pin to a new hole rotates the work to a new position a fixed distance from the first.

The indexer on Ed Hernandez's machine contains six concentric rings of small holes (one of 96 holes, another of 112, on through 120, 144, 192, and 240 holes). Using these holes, the turner can set equally spaced (or unequally spaced, for that matter) "stops" so that a pattern can be repeated. Rosettes, for example, could be incised around it. If you want 16, you can use the 96-hole ring and skip six holes each time you move the index pin. If you want 30, you might choose the 120-hole ring and skip four holes with each move.

The headstock also takes dozens of

Continued

This trophy cup, from the mind and lathe of Frank Knox, is made of wamara wood from Guyana. Handles are of pink ivory wood interlaid with a darker wood for strength. The trim? Remarkably, Du Pont's Corian, a synthetic marble. Knox considers the off-white Corian color a fine ivory substitute.

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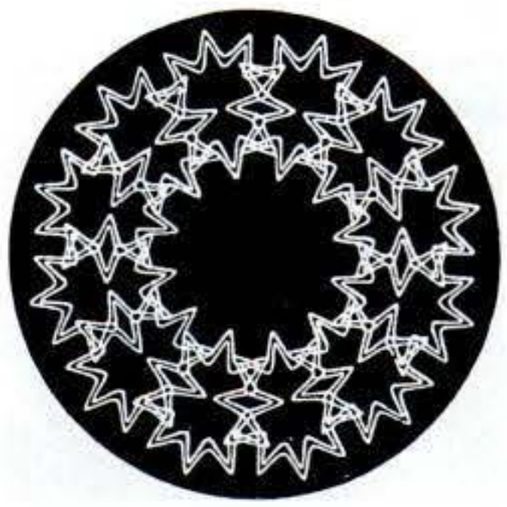
chucks that permit the work to be held in almost any conceivable position. One, for example, can hold a lead pencil by each end while the body is decorated. Another, the eccentric chuck, has a spindle that can be offset from the lathe's own spindle. A geometric chuck has spindles connected by an intricate arrangement of planetary gears. With it the tool remains stationary, but the work moves so that an epicycloidal curve is carved on it, similar to the lines made by a child's Spirograph toy.

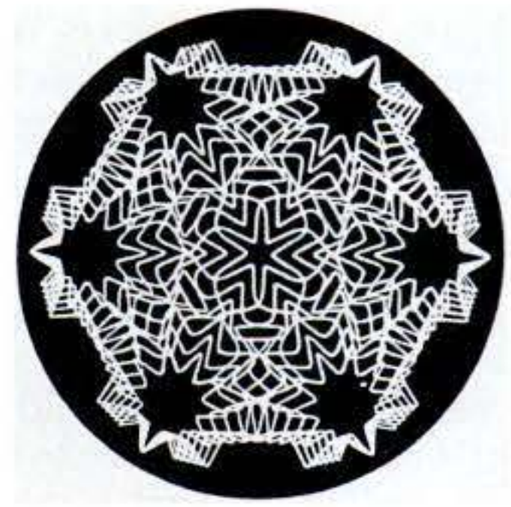


The elliptical chuck lets you turn an oval shape on a lathe; and you can ornament the oval.

In the cluttered office from which Ray Lawler runs the Lawler Gear Corp., he picks up a small oval bowl that lies among the books and sample turnings on the bed of his latter-day ornamental lathe, the prototype for the production run he is currently completing (see sidebar). The bowl's rim is decorated with an evenly spaced pattern of scallops and dimples. "How do you equally divide an ellipse?" he asks rhetorically. "A circle is easy to divide. With an ellipse the radius is ever-changing, so the spaces must be ever-changing. A device called a compensating index does that."

Victorian status symbol

The remarkable thing about a Holtzapffel lathe is that almost infinite permutations are made possible by all these components—and far too many others to mention. In Victorian England the lathes were such status symbols that some wealthy people bought them for their parlors. "They were even called parlor lathes," Ray Lawler reports. "People would hire craftsmen to entertain at parties."



"It's said that you could buy a row of tenement houses in London for what you had to pay for a lathe," says Calvin Lawler, Ray's father and another ardent admirer of the machines. For an original Holtzapffel today—if you could find one for sale—you'd pay $15,000 to $20,000, according to Ray. He set the price of his at $8,000 a copy for the first production run.

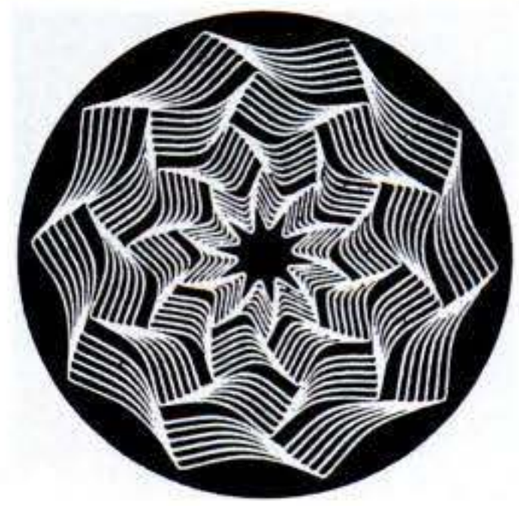
"Here we are with all the advantages technology permits us. Still, producing the machines has been one of the most demanding challenges we've ever faced," he says. "It gives you some sense of Holtzapffel's genius considering the technology he had to work with."

Ed Hernandez echoes that: "It simply is one of the most complex and brilliant inventions the world has ever seen. It is truly the ultimate tool." PS

Frank Knox sells copies of his illustrated book, *Ornamental Turnery*, for $24. Address orders to him at 2 Tudor City Pl., Apt. GG S., New York, N.Y. 10017.

Dover Publications (New York, N.Y.) has reprinted two volumes of original Holtzapffel books: *Simple Turning, Principles and Practice* and *The Principles and Practice of Ornamental or Complex Turning*.

For information on the Lawler lathe, write to Lawler Gear Corp., 10220 E. 65th St., Raytown, Mo. 64133.



MODERN MECHANICAL MARVEL

In a 1976 issue of *Fine Woodworking* magazine, Ray Lawler, a longtime woodworking hobbyist, read of a machine and craft he had never heard of before. The article was about Frank Knox, his Holtzapffel lathe, and the exquisite ornamental turnings Knox produces. "It was just fascinating," Lawler (left in photo) said, his voice still edged with awe.

Years passed before the bug gnawing at Lawler bit hard enough to make him act. Being the owner of a custom gear-making shop, Lawler's route to owning an ornamental lathe was not the usual search for an original. "We were in a slow period," Lawler recalled. "My Dad and I really wanted a lathe to play with. So we decided to make one." They also decided to see if they could sell three or four. Word got out and soon they had orders for 15.

"Frank Knox was the only man in the world I knew of who did ornamental turning," Lawler related. "So I called information in Manhattan and asked for his number. I got it and I called."

Lawler learned that the Holtzapffels had written five books on the lathe and turning techniques, two of which have been reprinted by Dover Publications. The books contain wonderful drawings of the machine, but give not a single dimension. So Lawler went to New York. "He spent two days in my studio with a micrometer and a camera," said Frank Knox. On the same trip Lawler visited Daniel Brush and his ornamental lathe collection. That was in 1984.

The Lawlers finished their prototype lathe in 1985. It is a beautiful machine, made of polished steel, cast bronze, and mounted on mahogany legs. (The 15 orders, delayed by consistently heavy demands on Lawler's production machinery, will be filled this spring.)

The Lawler lathe embodies several design changes. Of course it is motorized rather than having a treadle as the old ones originally did. It is also larger; it can hold work up to 36 inches long (compared with about 22 inches for a Holtzapffel lathe). "The material they were made for was ivory," Lawler explained, "and the ivory pieces were not big. Today most turners use exotic woods that come in larger pieces."

On the Lawler lathe the lead screw runs the length of the lathe bed. "The original machines had a lead screw only about eight inches long. If you had a longer piece, you'd have to move the slide rest down and start work again," Lawler said.

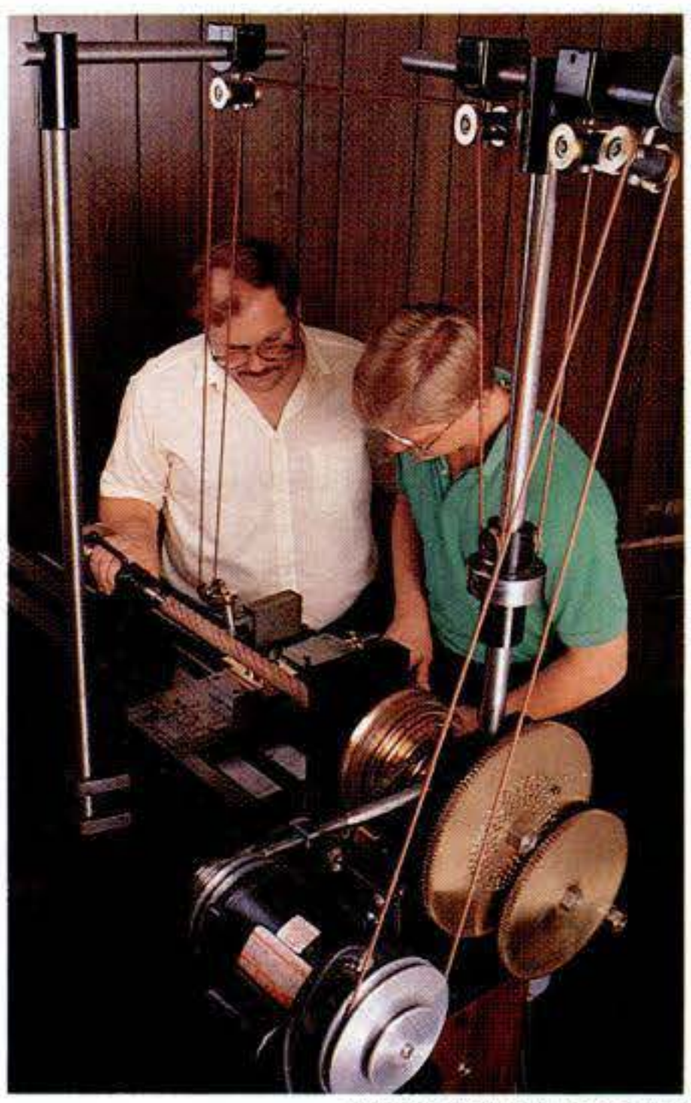


PHOTO BY MICHAEL A. MIHALEVICH

Because the slide rest moves over a longer length, so do the cutters. And the overhead drive that powers them must do the same. Lawler solved the problem by adding a vertical upright (left in photo) to the back of the slide rest, which moves in tandem with the tool holder. The pulley on the horizontal crossbar atop the upright thus can be always above the cutter. A counterweight on the main upright keeps the belt in proper tension.

None of this is patented. "Nobody else would be stupid enough to try making one," Lawler quipped.

The Lawlers made sure to keep many aspects of their lathe identical to the Holtzapffel originals. One reason: Those Holtzapffel books describe thousands of different ornamentations that can be produced using different combinations of components. By keeping critical dimensions the same, Lawler lathe users also can use these books. "We're lazy hillbillies," said Calvin Lawler with a grin. "We didn't want to write an owner's manual."—*V. E. Gilmore*

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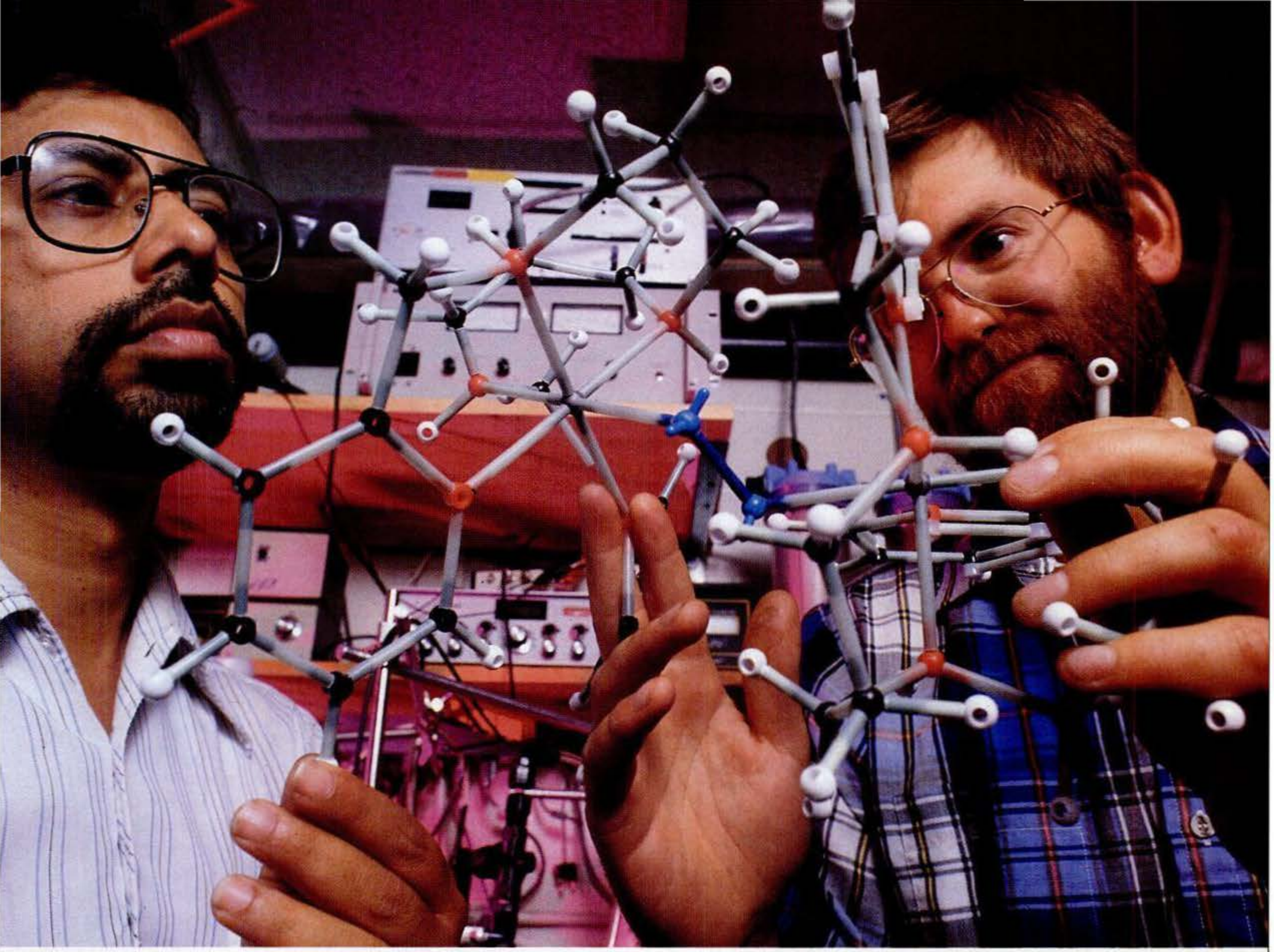

Aquanautics' director of engineering Dr. Sam Mohanta (left) and Dr. John B. Kerr, senior scientist, study a model of an experimental molecule that binds oxygen. Dissolved in fluid, it circulates throughout the artificial gill.

A device evolving in the lab contains a carrier fluid that mimics fish blood—it extracts oxygen from seawater. The carrier molecules can also draw oxygen out of beer and packaged foods, preventing spoilage.

ARTIFICIAL GILL

By DAWN STOVER
Photos by Marc Geller

EMERYVILLE, CALIF.

Scientists at Aquanautics Corp., a small biochemical research company, brew their own coffee in a machine outside the main laboratory. The coffee station is one of my first stops on a recent visit. While filling my cup, I notice a bar graph pinned to the wall. Below the bars, which record the opacity of various "carrier fluids," are names. Bruce is one. "What are these carrier fluids?" I ask Dr. Bruce Zenner, a biochemist and Aquanautic's chief scientist. "In this case, they're coffee," he says.

Zenner, who attends "board meetings" at a nearby windsurfing area is nonetheless a busy man who can appreciate a chemical like caffeine, and he and his colleagues probably have better things to do than measure the relative strengths of their brews. But carrier fluids are clearly uppermost in their minds. Because, in addition to coffee, they're conducting research on synthetic chemicals they've nicknamed "pseudoglobins." Like hemoglo-

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bin, the substance in blood that absorbs oxygen in the lungs and carries it throughout the body, pseudoglobin contains oxygen-binding molecules.

Pseudoglobins with the greatest affinity for oxygen are useful as scavengers: They can remove oxygen—an agent of decomposition—from foods and beverages. But perhaps even more useful are pseudoglobins that act as oxygen carriers. They not only *bind* with oxygen, but also can be induced to *release* it in another location. A system in which carrier molecules extract oxygen from air or water and deliver it to an oxygen-consuming cell is analogous to an animal's circulatory system. That's why Aquanautics calls the system an artificial gill.

Submarine-size sponges

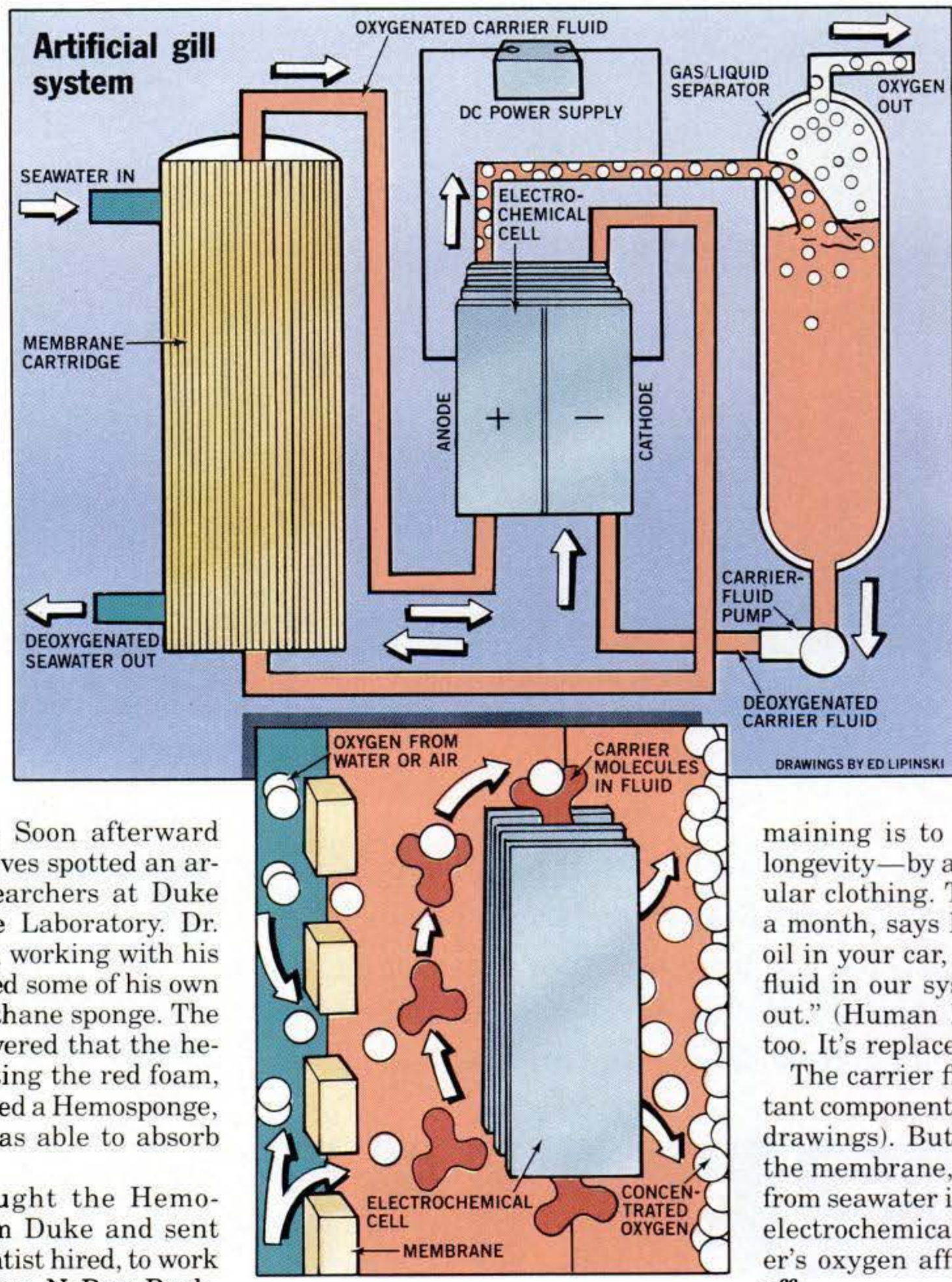
When I first heard about the gill, I imagined something scuba divers might wear on their backs—an underwater breathing machine. That was Aquanautics' original plan.

The company was formed in 1981 to pursue marine technology and immediately bought a wetsuit company. Soon afterward Aquanautics executives spotted an article about two researchers at Duke University's Marine Laboratory. Dr. Joseph Bonaventura, working with his wife, Celia, had mixed some of his own blood into a polyurethane sponge. The Bonaventuras discovered that the hemoglobin impregnating the red foam, which was later named a Hemosponge, stayed active and was able to absorb oxygen.

Aquanautics bought the Hemosponge patents from Duke and sent Zenner, the first scientist hired, to work with the Bonaventuras. N. Ross Buckenham, Aquanautics' 31-year-old president, recalls that one of the team's first assignments was to calculate the size of a Hemosponge needed to supply oxygen to a submarine. "They figured out the sponge would have to be bigger than the submarine towing it," says Buckenham.

The scientists were discouraged, but convinced that blood was the key to a new oxygen-extraction method. What about fish blood? they asked. It's pumped across a membrane to pick up oxygen, sent to the tissues to unload the oxygen, and returned to the membrane to reload. Zenner knew he could make a circulating fluid that would grab oxygen. What he needed was a way to make it let go.

In the human body an increase in the blood's acidity loosens hemoglobin's grip on oxygen when it reaches the tissues. Electrochemists, working with Zenner, found a second way to regulate hemoglobin's affinity for oxygen—with electricity.



Detail (above) shows the molecular interactions occurring in the gill (top). Seawater (green) and a carrier fluid with an affinity for oxygen (red) enter a cartridge, where they exchange gases across a membrane. The carrier molecules, bound to oxygen culled from the seawater, travel to the anode of an electrochemical cell, which provides the energy needed to "switch off" their oxygen affinity. Oxygen bubbles out and is separated from the liquid. The fluid returns through the cell's cathode, which switches its affinity back on.

The first experiments were with animal hemoglobin. "But hemoglobin's a huge molecule," says Buckenham. "It does a lot of things in your body other than binding oxygen." So the scientists worked with hemes, the four iron-containing molecules in hemoglobin that are bonded to the globin protein. Finally, the researchers began making their own oxygen-binding molecules.

Like heme, the synthetic molecules have a metal core—maybe cobalt or manganese (Aquanautics isn't telling). Attached to the central metal are five organic molecules, with a sixth site available for oxygen to bond. The fake hemes are about the size of genuine ones, explains Zenner, "and they're very water-soluble."

I inspect a tube of fluid containing one of the artificial carriers. It looks like blood, only darker. "Our carriers are much more concentrated than hemoglobin," Zenner says.

Over the last few years the researchers have spent most of their time screening oxygen carriers—more than 200 in all. The biggest challenge remaining is to improve the carriers' longevity—by adding protective molecular clothing. The carriers last about a month, says Buckenham. "Like the oil in your car, we have to change the fluid in our system because it wears out." (Human hemoglobin wears out too. It's replaced every few months.)

The carrier fluid is the most important component of the artificial gill (see drawings). But there are two others: the membrane, where oxygen diffuses from seawater into the carrier; and the electrochemical cell, where the carrier's oxygen affinity is turned on and off.

Reinventing nature

When Zenner and his colleagues abandoned the Hemosponge and instead began developing a circulating system, they were following nature's lead. They're doing that again as they study the gill's membrane. "When you come up against roadblocks, it's amazing how you can go back and look at what nature has done to solve these problems," says Buckenham. "It's use-

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ful to see how a fish membrane is structured to get the maximum amount of oxygen from the smallest volume of seawater."

Most of the membrane cartridges Aquanautics has tested are sold by hospital suppliers for oxygenating blood during cardiac-bypass surgery. From a distance, some cartridges look like bundles of thin spaghetti. Others look like skeins of tightly wound string. Either way, they contain oodles of tiny hollow fibers "made in a fashion that's similar to the way they make Gore-Tex," Zenner explains. "They're stretched, and this creates microvoids; they look like stretch marks." The microscopic holes repel water and hydrophilic (water-loving) molecules, but allow oxygen to pass.

Next to the gill apparatus in the lab, a tank that looks like a large water heater oxygenates "seawater" (it's really Instant Ocean, a product made for aquariums). The seawater, pumped through the core of the membrane cartridge, seeps out around the fibers, which are filled with carrier fluid, and oxygen diffuses into the carrier.

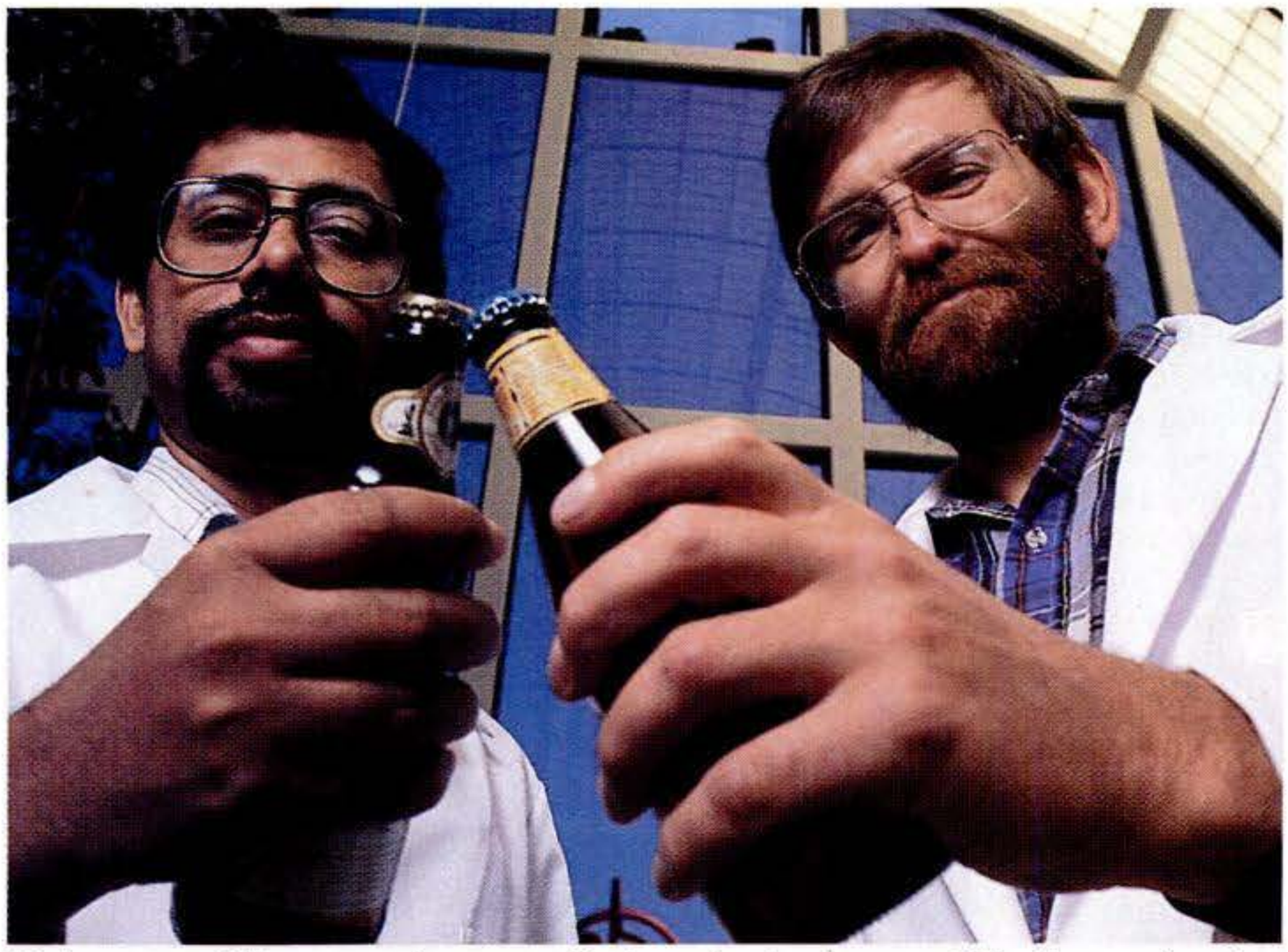
The oxygenated fluid then flows to the electrochemical cell, which is "like your car battery in reverse," Buckenham explains. "Instead of generating power like a battery does, you actually put electricity *into* the cell."

The fluid goes first to the cell's anode, where an electron is removed from the carrier molecule. That lowers its affinity, releasing the oxygen. The fluid and oxygen bubbles travel to a phase separator, where they part company. The carrier fluid goes back to the electrochemical cell—this time to the cathode, where it gets back the electron it lost. That puts the molecule back into its high-affinity state.

The scientists are still looking for ways make it easier to switch the carrier molecules on and off. For example, they've designed their own electrochemical cell. It's the same size as commercially available units, but has more than twice the surface area.

Aquanautics tested an artificial-gill prototype in January 1988. It was hooked to an aluminum-air battery that needs oxygen to operate. "We wanted to show that we could get more energy out of the system than we put in," says Zenner. The demonstration was a success. "We were able to continuously produce more than twice as much power as was consumed by the gill," reports Dr. Sam Mohanta, Aquanautics' director of engineering.

When Aquanautics filed its first patents on the switching system, the gill took a kilowatt of energy to produce one liter of oxygen per minute (enough for two people at rest). By July 1988 energy consumption had been reduced from 1,000 watt-minutes per liter to 25. And the resulting oxygen was at least 98 percent pure, says Mohanta.



Mohanta and Kerr toast Aquanautics' synthesis of oxygen-binding molecules. Called Longlife, the molecules could be used to filter oxygen out of beer before packaging or be incorporated in caps to keep bottled beer fresh.

Theoretically, energy consumption could be reduced to 10 watt-minutes per liter, the company claims. That's far more efficient than electrolysis (breaking water into hydrogen and oxygen), which has a theoretical energy consumption of 376 watt-minutes per liter and an actual consumption of about 600. Cryogenic (low-temperature) processes are more efficient—anywhere from 35 to 100 watt-minutes per liter—but only on a large scale.

Cryogenics are used to separate oxygen from air, and the artificial gill can do that too. Air contains about 30 times as much oxygen by volume as does water at the same temperature and pressure, so it's even easier to make an artificial "lung" than a gill. In fact, the same basic technology can be used for a variety of applications:

- *Underwater vehicles.* At one time, the U.S. Navy envisioned an unmanned torpedolike vehicle that could cruise around the ocean, listening for enemy submarines. "It would be very much like a fish," says Buckenham. "It would breathe water, extract oxygen from the water, and use that oxygen to propel itself. Of course, you've got to take down a fuel that will combust with oxygen."
- *Underwater stations.* "If you put a battery under the ocean, it will only last a few days," says Buckenham. That's why the Navy is interested in constructing outposts powered by oxygen-consuming fuel cells. A gill placed on the bottom of the ocean could be used to operate equipment for surveillance or oceanographic surveys.
- *Personal medical devices.* Aquanautics wants to build respirators that would emancipate outpatients from bottled oxygen. "The ideal size would be something like this," says Buckenham, holding up a book. "You could put a battery pack in, strap it to your waist, and be able to walk around for three or four hours."
- *Industrial oxygen.* Blowtorches burn oxygen and acetylene to produce high-temperature flames for welding and cutting. They consume huge quantities of oxygen.
- *Life-support systems.* The gill could provide oxygen for breathing inside a submarine, aboard an aircraft at high altitudes, or during chemical warfare. At NASA's request Aquanautics has also investigated the possibility of using a gill on Mars. Oxygen is even rarer there than in the ocean—it's less than 0.3 percent of the atmosphere. But a feasibility study done by Aquanautics claims it's possible to extract oxygen on Mars.

The ugly ducklings

Aquanautics rejected most of the 200 or so molecules tested for possible use as carriers. "We realized that there was going to be a range of oxygen affinities that were appropriate for use as an oxygen production system, and that too high an affinity was not good," says Zenner. High-affinity carriers act like magnets; it requires great energy to

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DECK UNDER GLASS

This problem-solving redwood deck rises over a steep hillside in Southern California. A tempered glass rail preserves the view while it shelters the deck from prevailing winds. Your own problem-solving deck could win you $1,000 in our exclusive contest.

By RICHARD L. STEPLER

Problem: Tame a Southern California hillside for outdoor living yet preserve the panoramic view of the Pacific Ocean overlooking a golf course. Complicating the situation: prevailing winds that could make sunning and alfresco dining on the deck windy propositions. The owners of the home, a 20-year-old Spanish-style tract house, also didn't want simply a basic square deck.

Solution: A dramatic, irregularly shaped multilevel redwood deck with a tempered glass railing that shields the deck from onshore breezes yet does not hide the view.

Designer Dana Nadeau of Capistrano Beach, Calif., took advantage of the apparent drawbacks of the site—an irregularly shaped lot as well as the steep terrain—to create a deck with several levels and irregular angles, avoiding the look of the basic square or rectangular deck.

Defining levels

The deck's several levels are defined by differing orientations of the 2×6 redwood decking; this adds visual interest and defines deck areas, as well

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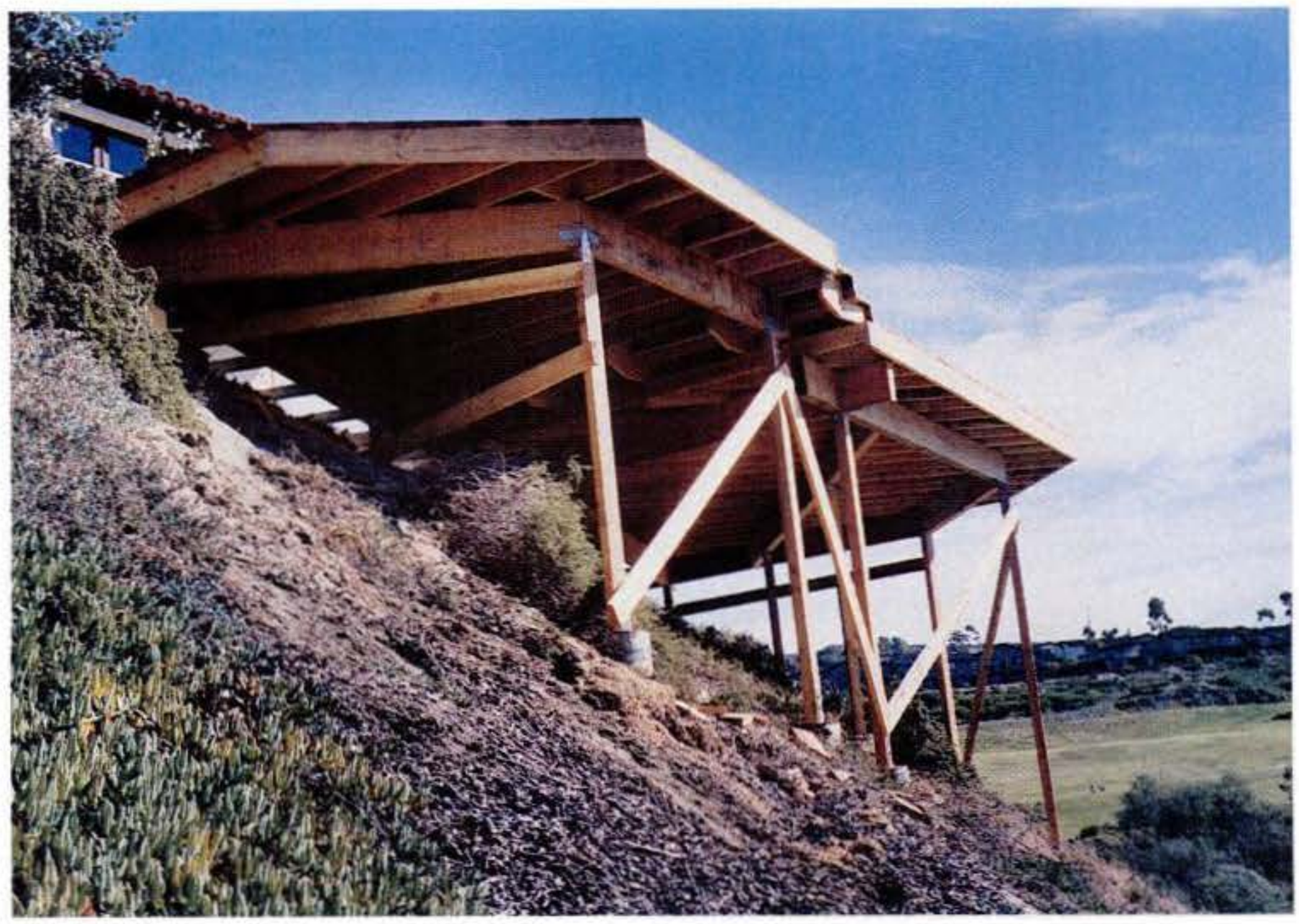
PHOTOS BY MARK BECKER

Glass railing retains the view (below) yet provides shelter for the spa (above). Deck levels are defined by differing orientations of decking. Before view (facing page) reveals the steep hillside the deck reclaims.

as aids in preventing tripping accidents. The deck's lowest level, down two steps from the main section, is actually cantilevered over the hillside. The second section is built at ground level. A third, raised section wraps around the spa, which is also built on ground level (see floor plan on a following page).

The decking and all visible wood is redwood. The clear and select grades used are free or relatively free of knots and show streaks of lighter colored sapwood. The understructure of the deck is constructed of fir and pressure-treated fir.

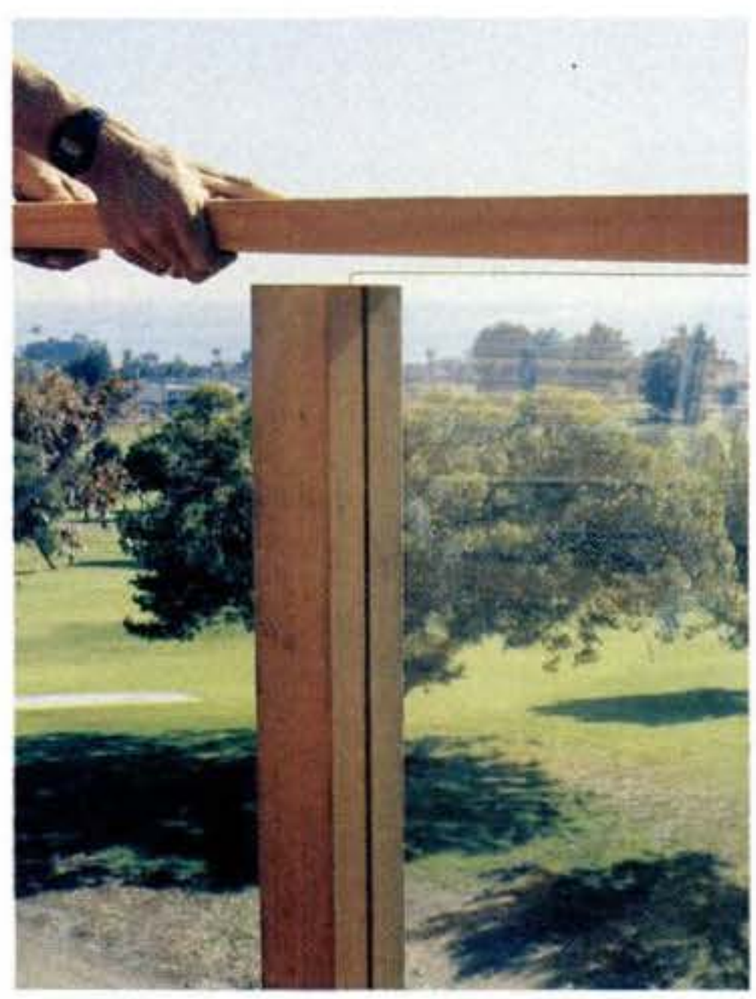
The deck was built in segments, with the cantilevered section first. It's supported on 4×4 posts set into 12-inch-diameter concrete piers that are dug 54 inches into the hillside. The concrete piers were poured into Sonotube forms. The posts support 4×12 headers, which in turn support the 2×8 joists under the 2×6 deck surface. Galvanized joist hangers reinforce the construction. Cross bracing for the support posts is also 2×6.



Though it appears to float from above, deck is firmly anchored to the hillside when seen from below (top). Twelve-inch-diameter concrete footings (poured in Sonotubes) support 4 × 4 posts. Cross bracing members are 2 × 6s. Vertical supports for glass are double-lag-bolted to deck edge (left). Posts are dadoed to accept glass inserts, as are 2 × 6 top caps (below).

Construction tips

The deck railings are 46 inches high. Upright posts, double-lag-bolted to the face of the deck, are dadoed to hold tempered glass inserts and are capped with 2×6 vertical-grain redwood. Shorter, alternating sections of vertical redwood slats break the visual monotony of the glass and help to define the deck areas.



The ground-level section of the deck is supported on 4×4 pressure-treated joists, which rest atop concrete piers (see section drawing on the facing page). A third, raised section built around two sides of the Sundance acrylic spa hides the plumbing and electric service, as well as provides easy access to the whirlpool. The spa, which has its own redwood surround, was simply set in place and the deck was built around it. A redwood lattice privacy screen completes this section of the deck.

All exposed redwood is finished with Watco oil-based semi-transparent stain. PS

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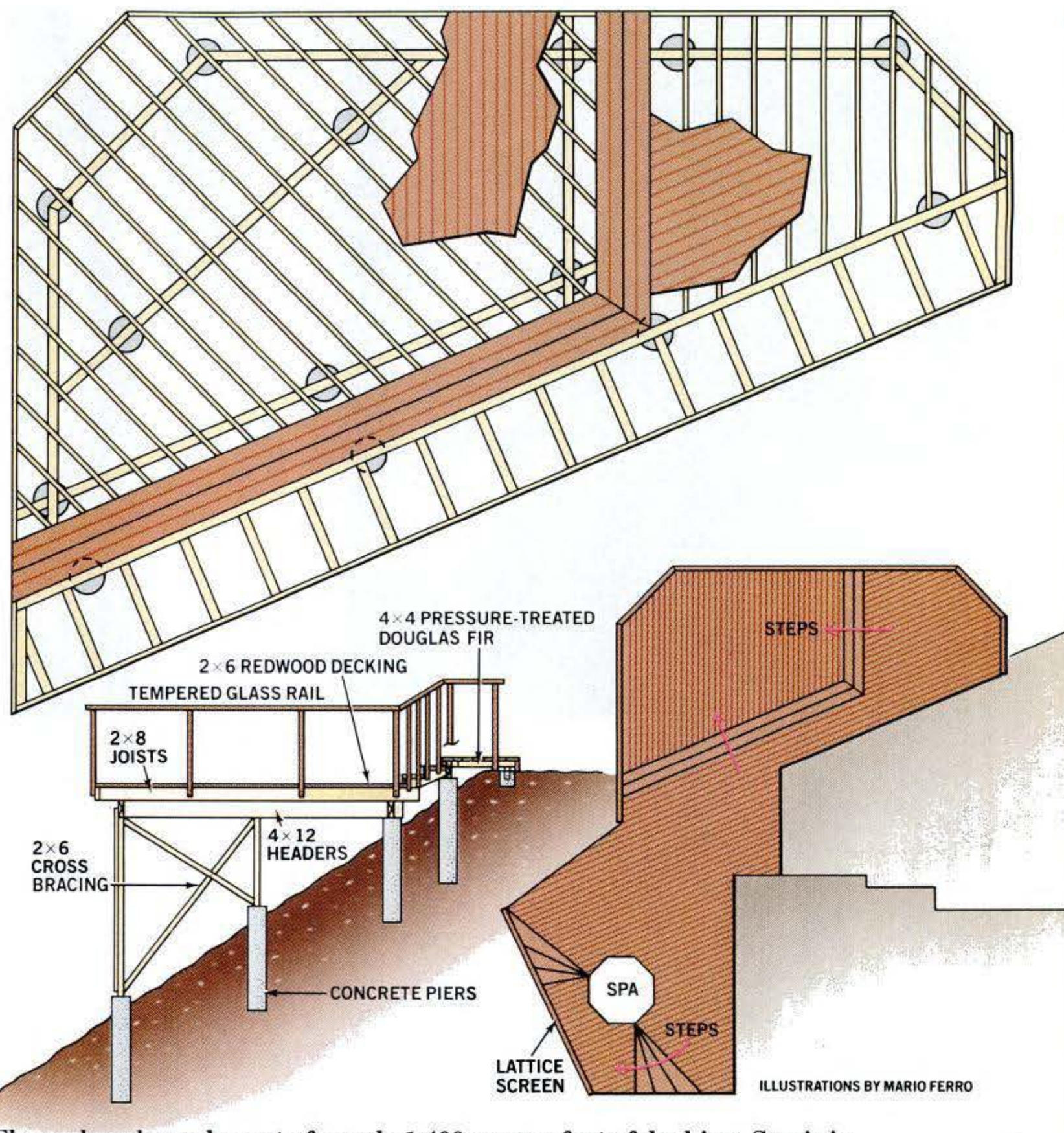
WIN $1,000 WITH YOUR PROBLEM-SOLVING DECK

Have you built a deck recently or are you planning to add one to your house soon? POPULAR SCIENCE and the California Redwood Association are looking for the best decks in the United States. We will award one grand prize of $1,000 plus four other cash prizes. The winning decks will be featured in a future issue of POPULAR SCIENCE.

Only decks that use redwood in their construction qualify, and the deck must solve a problem: provide access from the house to the yard; include built-in storage for sports or barbecue gear; surround a swimming pool or spa.

If you need help designing a new deck, send $1 to the California Redwood Association (address on coupon below) for a Deck Builder's Starter Kit. It includes an idea booklet, a manual on deck construction, and several tip sheets on specific projects such as building decks around hot tubs or over concrete slabs and adding benches and planters.

Here are the details of the POPULAR SCIENCE/ California Redwood Association Problem-Solving-Deck Contest:



ILLUSTRATIONS BY MARIO FERRO

Floor plan shows layout of nearly 1,400 square feet of decking. Spa is in sheltered area next to house, while areas for sunning and enjoying the view are cantilevered over the bank.

- **PRIZES:** A check for $1,000 goes to the grand winner. In addition, there are two secondary awards of $500 and two third-place prizes of $300 each—a total of five prizes. All five decks will be featured in a future issue of POPULAR SCIENCE.

- **HOW TO QUALIFY:** Your deck must use redwood in its construction, preferably for all visible surfaces. Other materials may be used for structural support, as in the example deck on these pages. Your deck should be functional as well as good-looking and should solve at least one problem: conceal an eyesore, provide privacy, tame a difficult site. Decks built since July 1988 are eligible if they meet the above criteria, have not been published elsewhere, and can be attractively photographed. Employees of POPULAR SCIENCE and the California Redwood Association are ineligible.

- **HOW TO ENTER:** Fill out the entry coupon or list all information the coupon calls for on a separate piece of paper. Enclose at least one clear photograph (a black-and-white or color print preferred, but a color slide is acceptable). Include a dimensioned drawing calling out the nominal sizes of each redwood member (for example: 4×4 post, 2×6 joist, 2×4 decking); a rough pencil sketch will suffice if it's labeled with critical dimensions. Also include a list of all materials used: redwood, other lumber or plywood, hardware, finishing materials. Specify what problem(s) the deck solved and include special construction tips you'd like to pass on to anyone attempting to adapt your project to his own site.

If no publishable photo is supplied, POPULAR SCIENCE and the California Redwood Association reserve the right to arrange photography at your convenience (and their expense). However, failure to supply at least a snapshot of your deck will disqualify the entry. And the better the photo(s) you submit, the better the judges will be able to evaluate your project.

Entries must be delivered to the address shown on the coupon by Aug. 15, 1989. Upon delivery, publication rights belong exclusively to the California Redwood Association and POPULAR SCIENCE, unless neither exercises the option within a period of six months.

No entries can be acknowledged except the five chosen winners, and none will be returned unless accompanied by a written request and a self-addressed envelope with proper postage. Do not submit models or presentation boards over 18 by 24 inches. Blueprints of any size are acceptable.

- **JUDGING** (by representatives of POPULAR SCIENCE and the California Redwood Association) will be for the most effective use of redwood in a problem-solving deck. Winners will be notified by Sept. 15, 1989.

ENTRY COUPON (Clip and attach to your photo)

Mail entry to:
POPULAR SCIENCE/CALIFORNIA
REDWOOD ASSOCIATION CONTEST
405 Enfrente Dr., Suite 200
Novato, Calif. 94949

To qualify, entry must reach Novato address by Aug. 15, 1989

YOUR NAME (print or type) _____

ADDRESS _____ Daytime Phone No. _____

CITY _____ STATE _____ ZIP _____

Check one:

☐ My signature certifies that this project is of my own design and has not been published elsewhere.

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(Sign) _____

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6 Summer houses for year-round living

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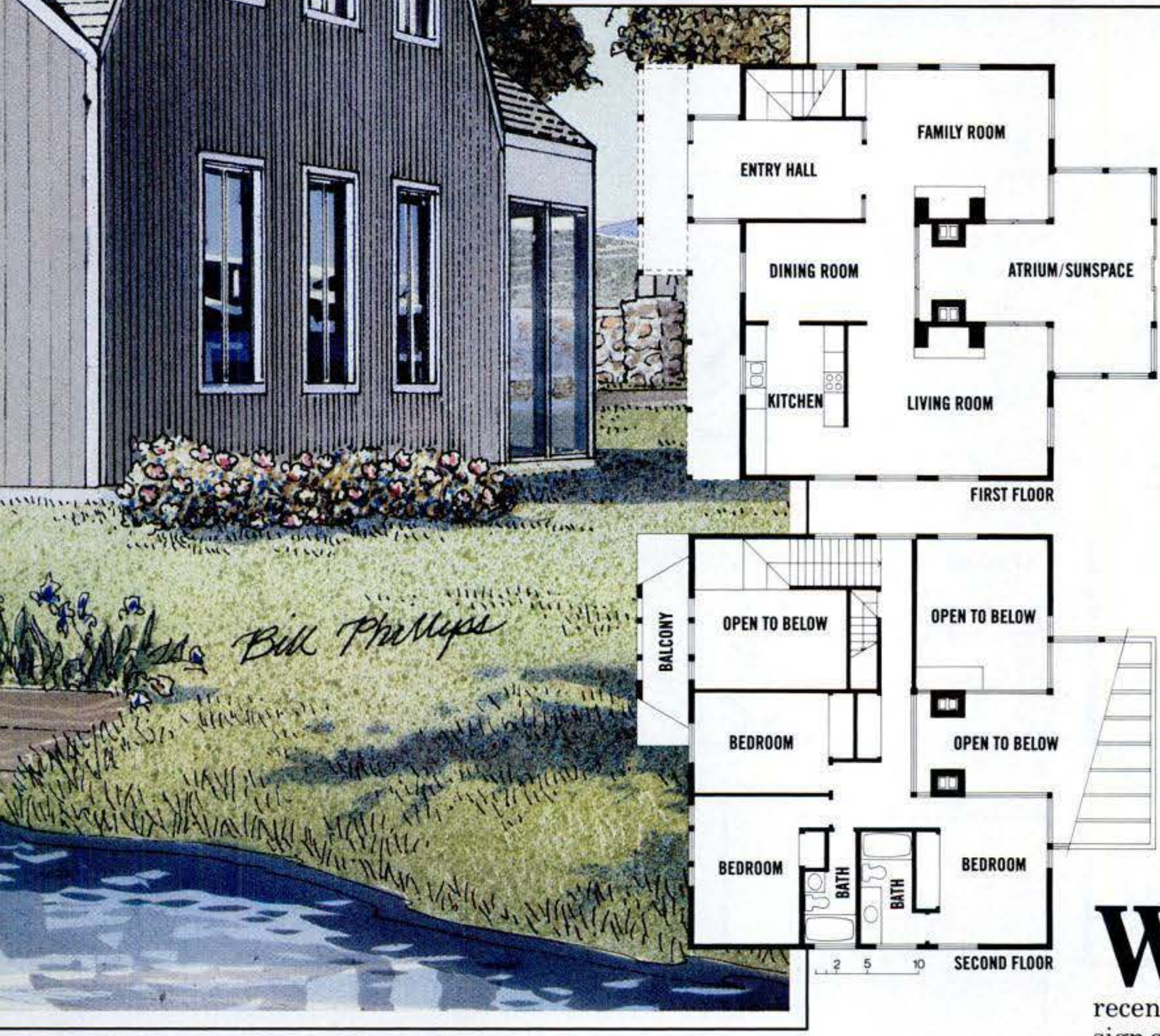
RENDERINGS BY BILL AND MERIKE PHILLIPS



ATRIUM HOUSE

The latest design from Alfredo De Vido combines the appeal of sunny semi-outdoor spaces with energy-efficient features. The heart of this house and its conservation system is a sun-oriented patio that draws solar heat through its glass roof and holds it in the masonry mass of its paved floor. Energy-saving aspects include a compact shape with a minimum of exterior surfaces; air-lock vestibules at front and back; and insulating shutters. Window walls close off the house when the atrium is cool. This same glazed core helps cool the house in summer by letting warm air escape through a top vent.

Though all can serve as primary housing, there's something special about the half-dozen homes in this portfolio that says "lazy-day fun." Commissioned from five prizewinning architects, three of the houses are earth sheltered and the others make a point of tapping into passive solar energy.

By AL LEES

When I contacted the five architects whose house plans had been reader favorites in our recent portfolios, I asked each to design a home for POPULAR SCIENCE readers—a home that comfortably embraces today's technologies and bolder sense of design without sacrificing traditional comforts.

One architect found the challenge so stimulating that he submitted two houses; the others presented flexible designs that will adapt to a variety of sites. **For data on ordering plans, see the last page of this portfolio.**

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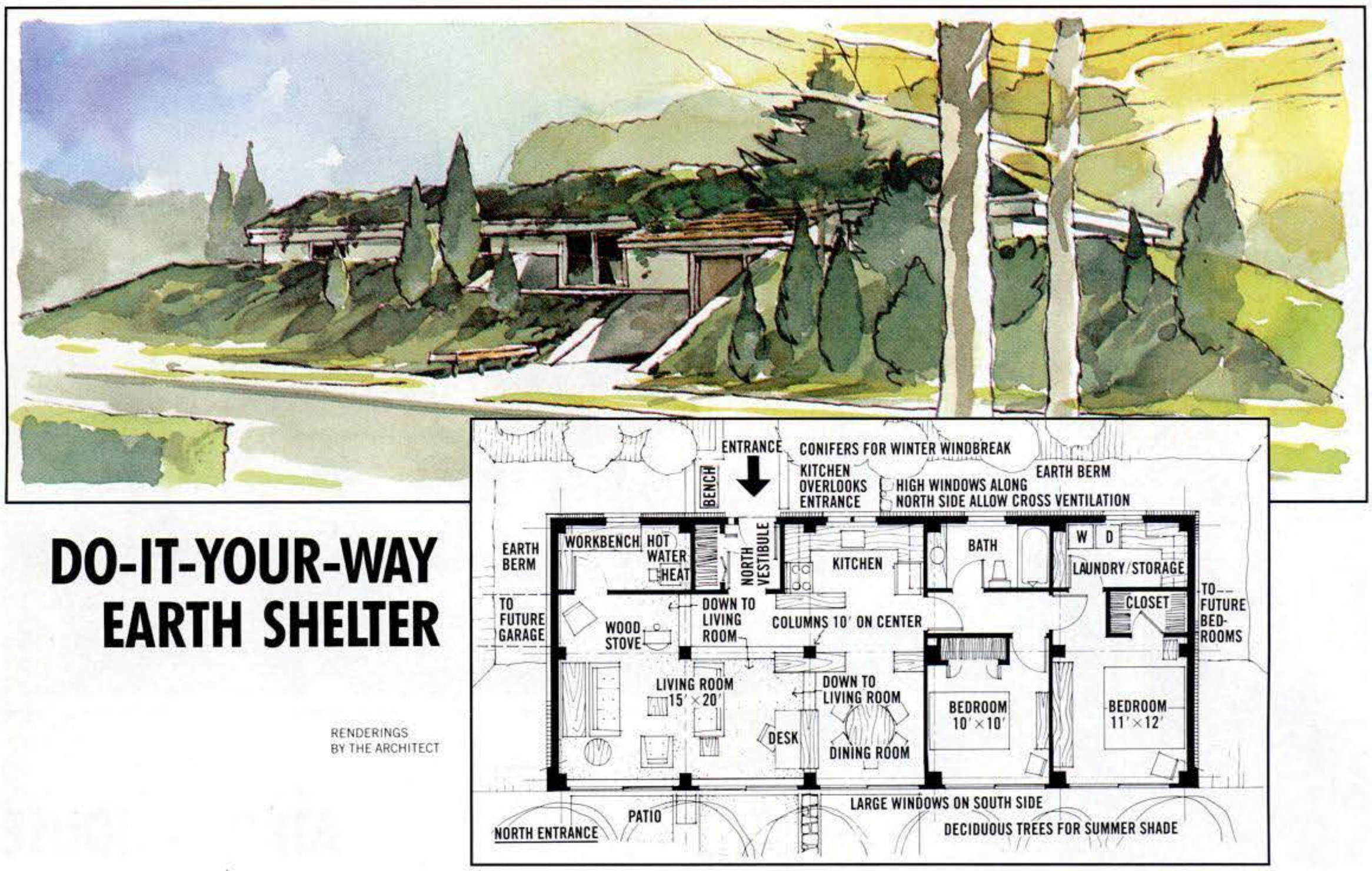

DO-IT-YOUR-WAY EARTH SHELTER

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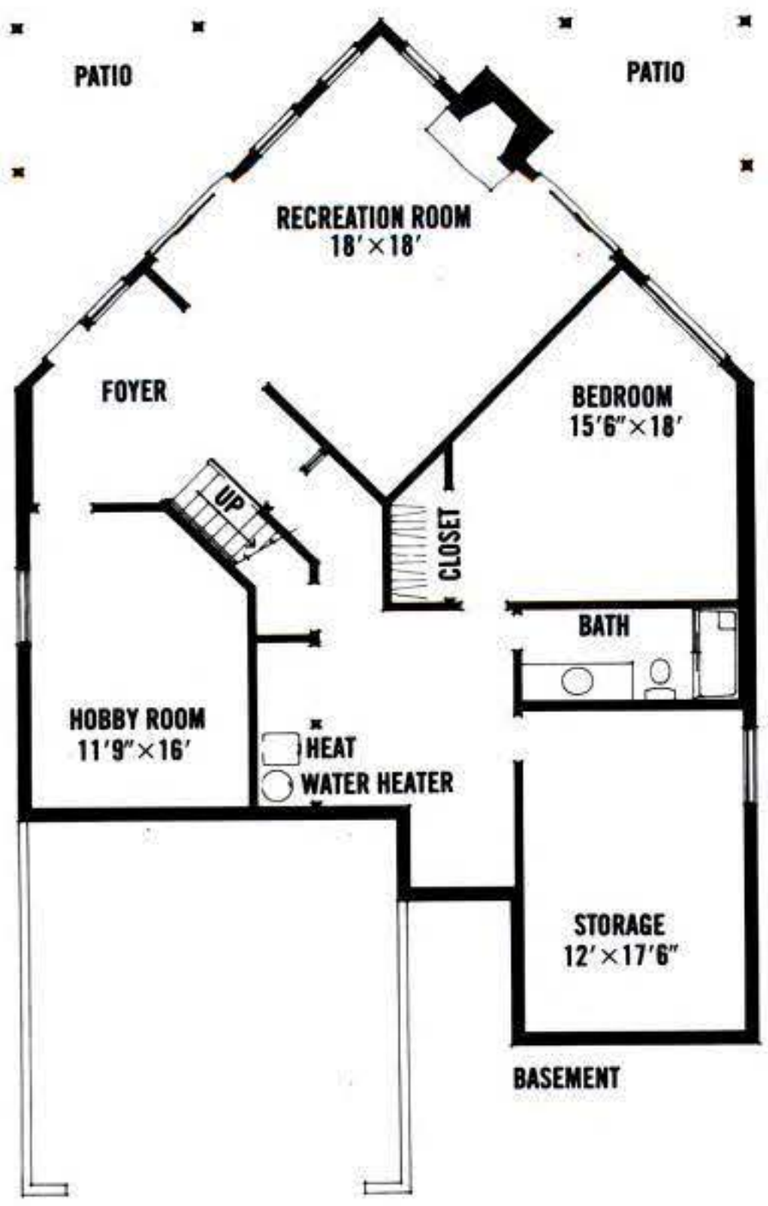
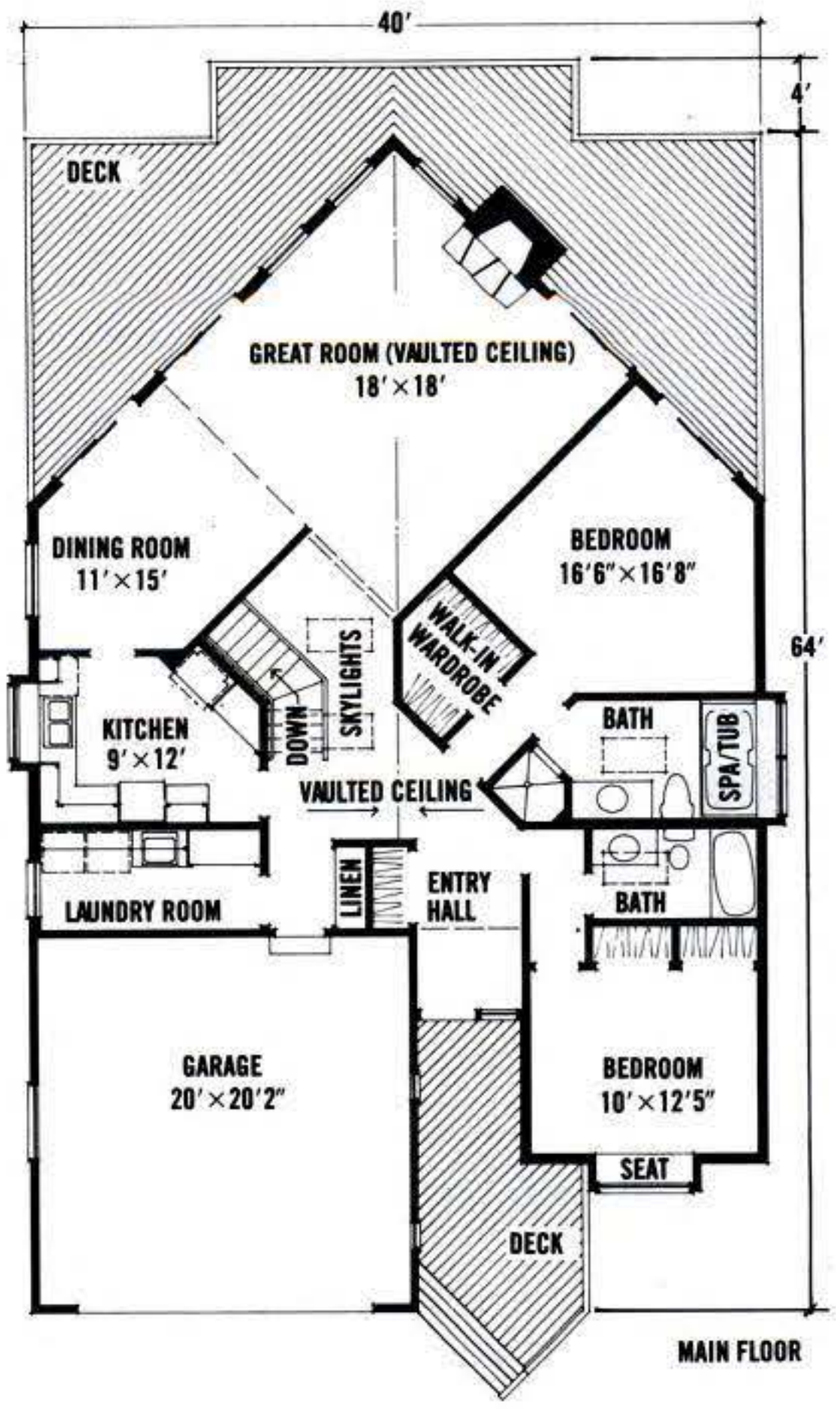
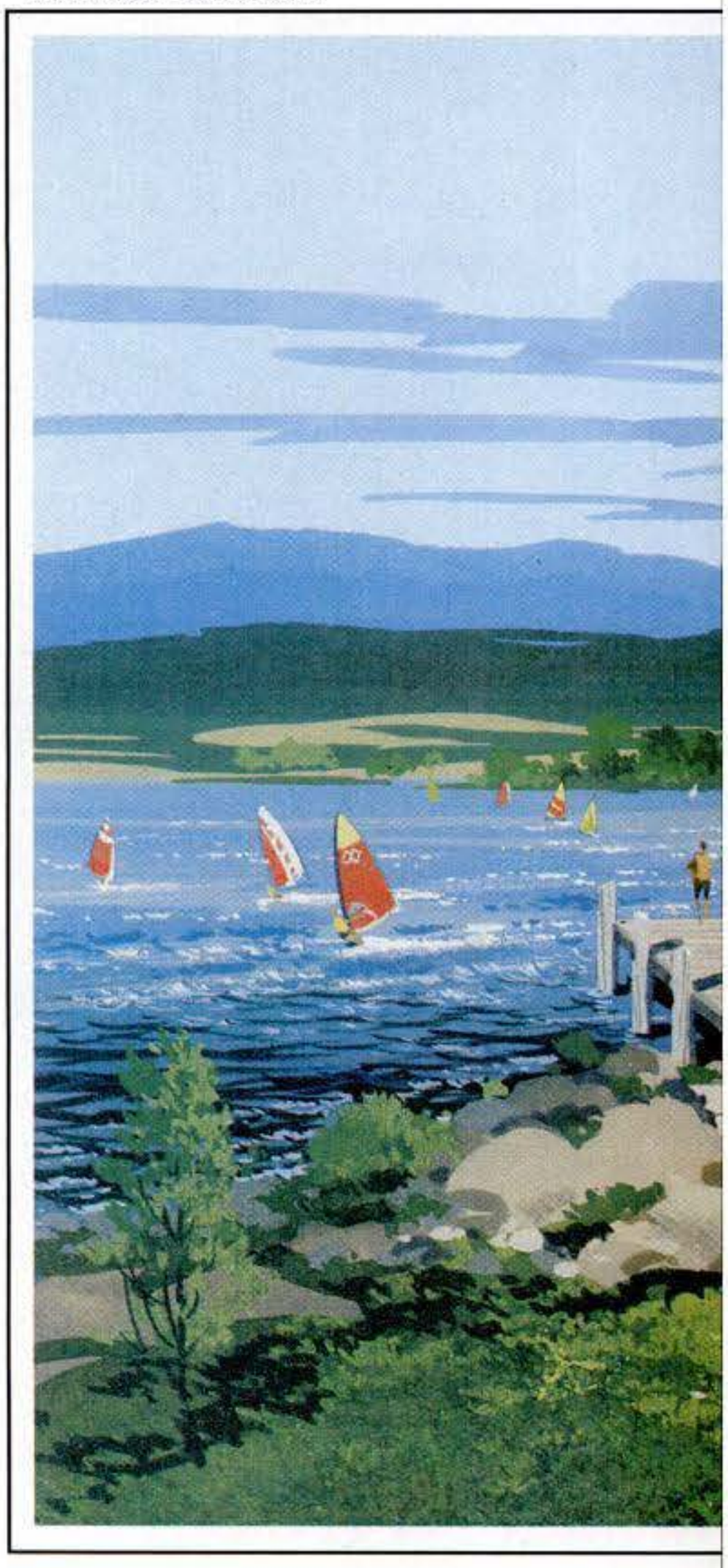




RENDERING BY CARL LAUERSEN



TWO-STORY PROW

Designed for fullest use of a narrow lot with the major view at the back (the case with most waterside or canyon sites), this house offers a sweeping vista through a two-story window wall that wraps around the great-room fireplace. The stone chimney, shake roof, and vertical cedar siding tie the house to any natural setting, but will also make a design statement on a city lot. An angled deck invites visitors into a snug and partially covered entry.

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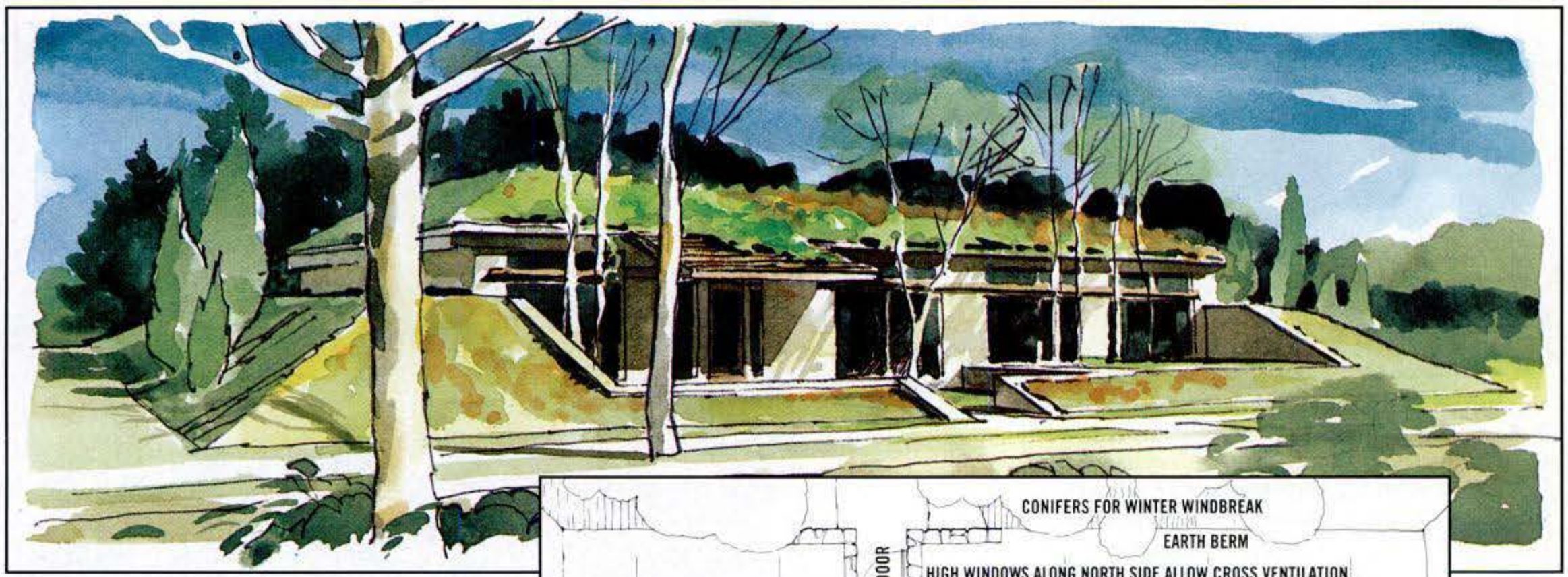
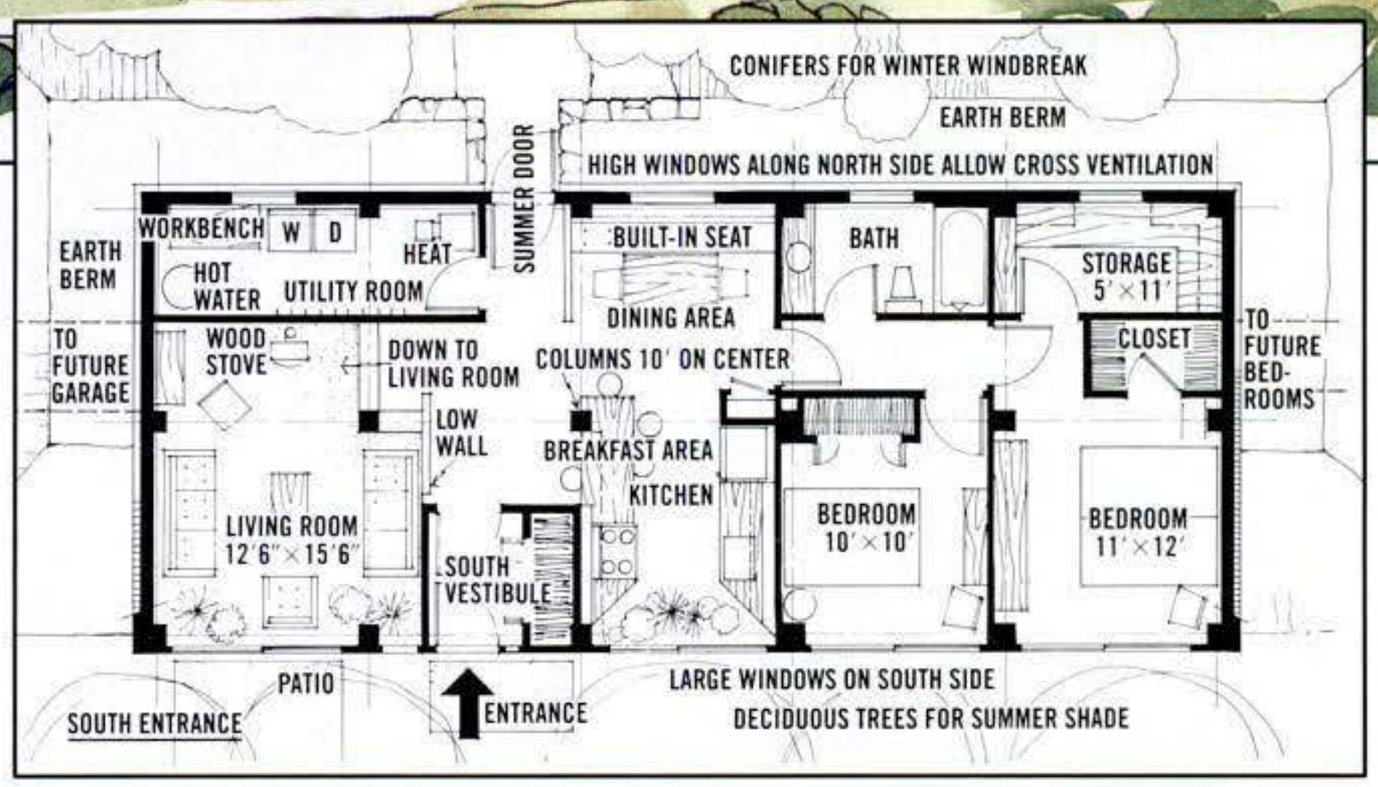
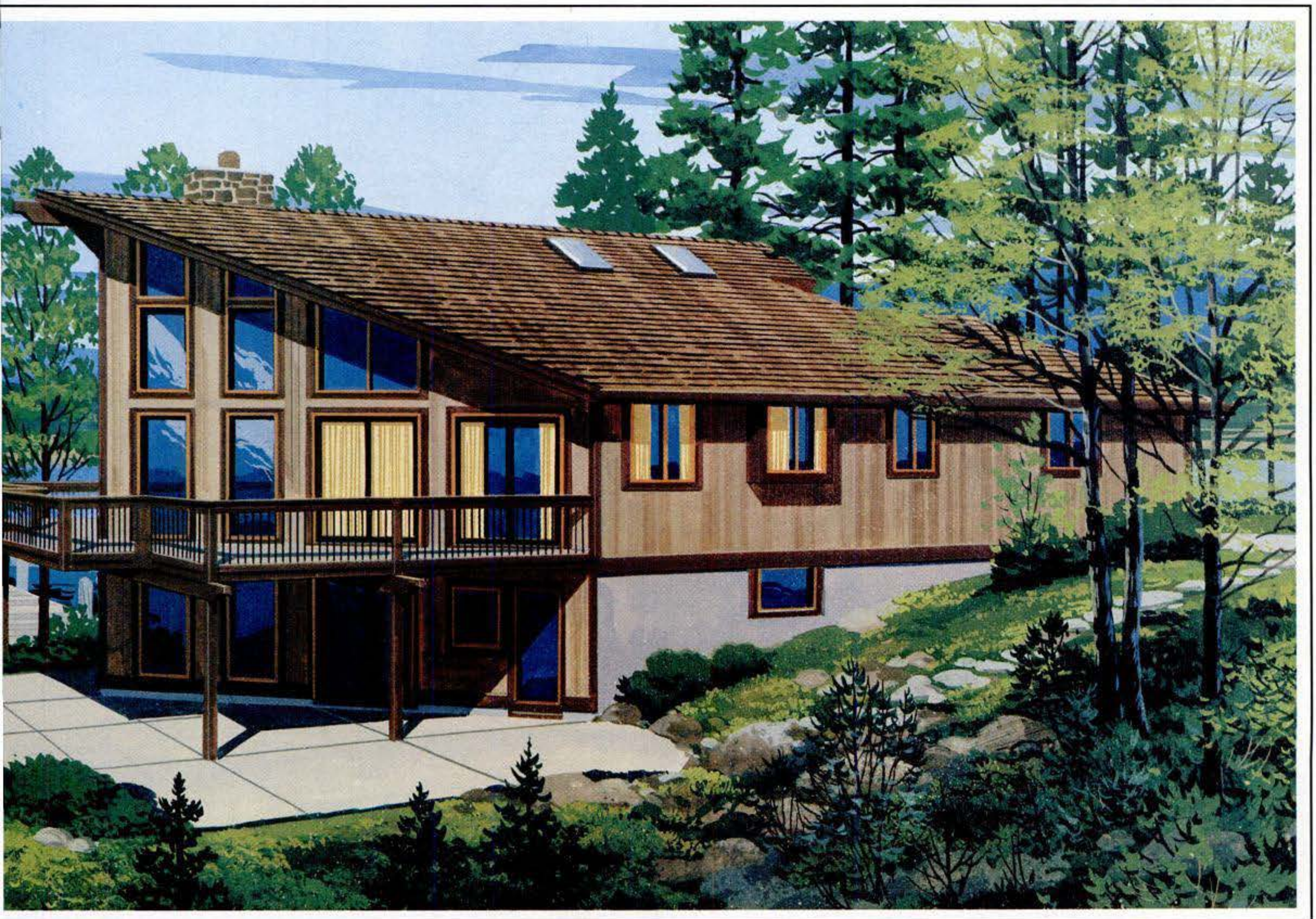




Flat land, hilly land, north slope, south slope—you name it, this 1,000 square-foot two-bedroom house by Cape Cod-based architect Malcolm Wells offers two floor plans to fit almost any snow-belt site. Farther south, where air conditioning is the main concern, a south-to-north reversal solves the orientation problem. Columns support a timber-and-joist deck that carries a rooftop wildflower garden. A simple duct system pulls solar-heated air down into the floor mass.



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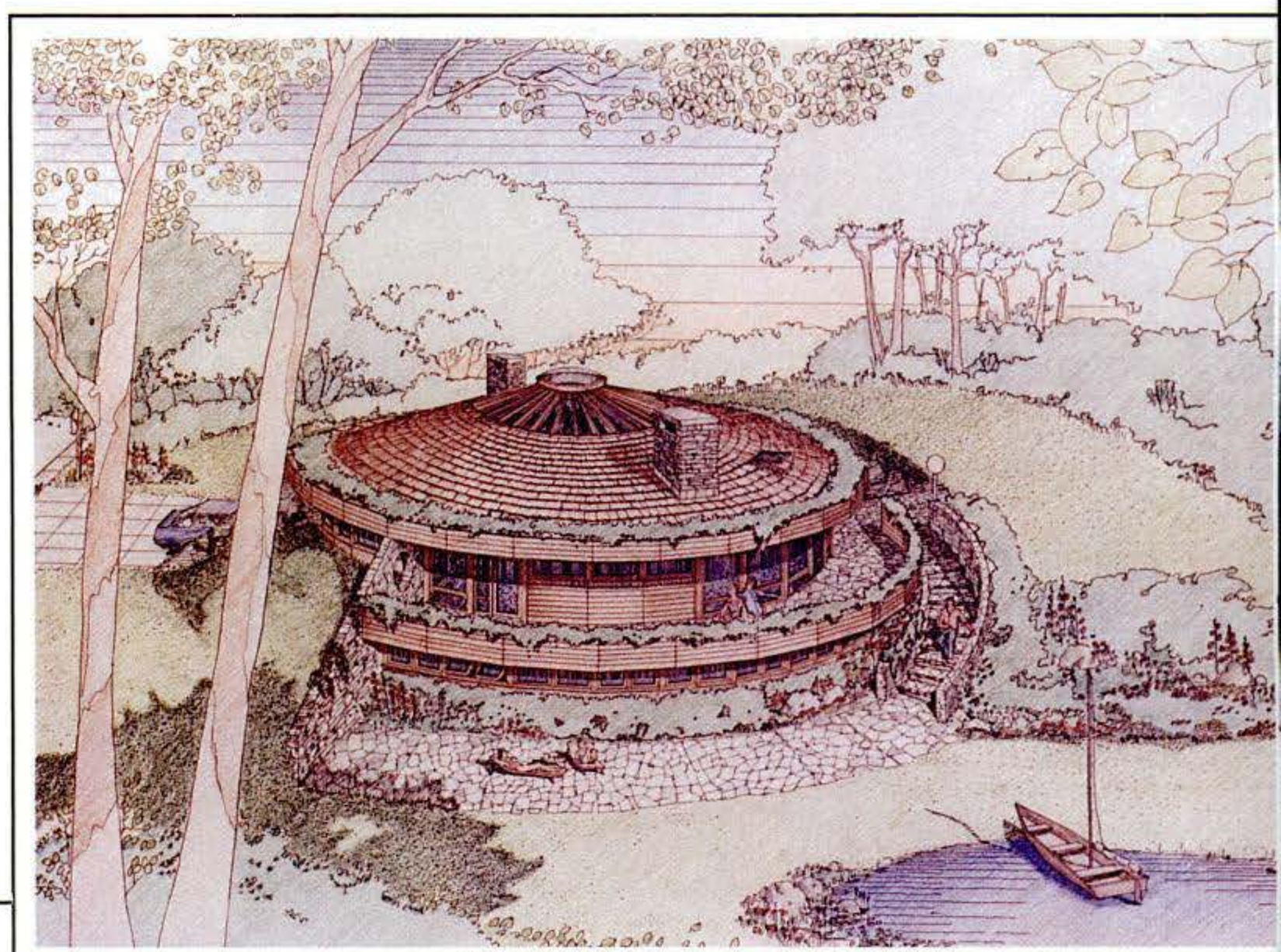
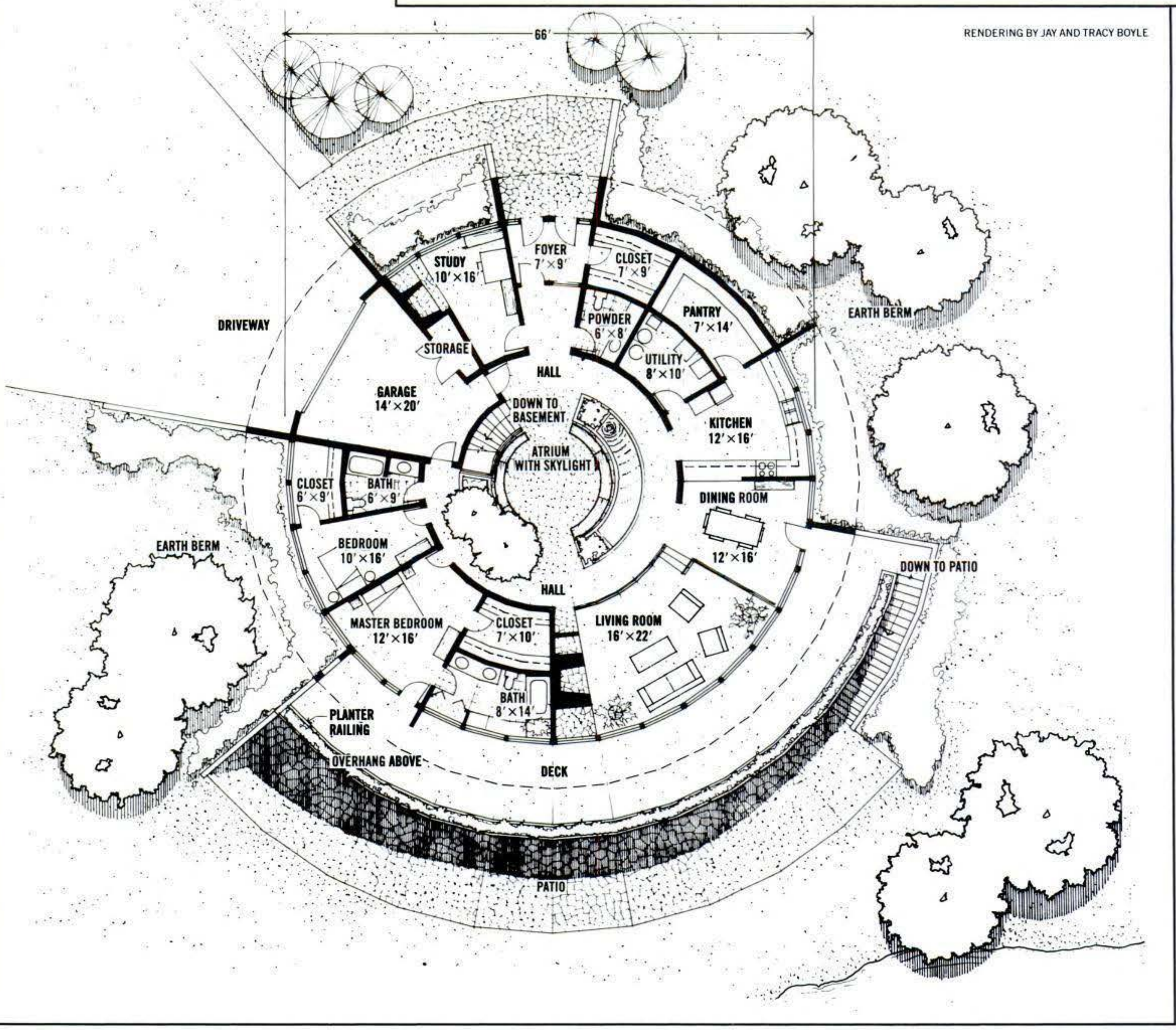
RADIANT HOUSE

Designed by Charles G. Woods (who lives in one of his underground houses), the Radiant is a 3,500-square-foot house with protective earth berms on all but its south-facing chord. Construction plans include a section for building a single-story version on a flat lot, with an optional 1,750-square-foot basement. The wedge-shaped rooms radiate from a central skylighted atrium, and several of them open onto a wraparound deck, with steps down to a patio.



RENDERING BY JAY AND TRACY BOYLE



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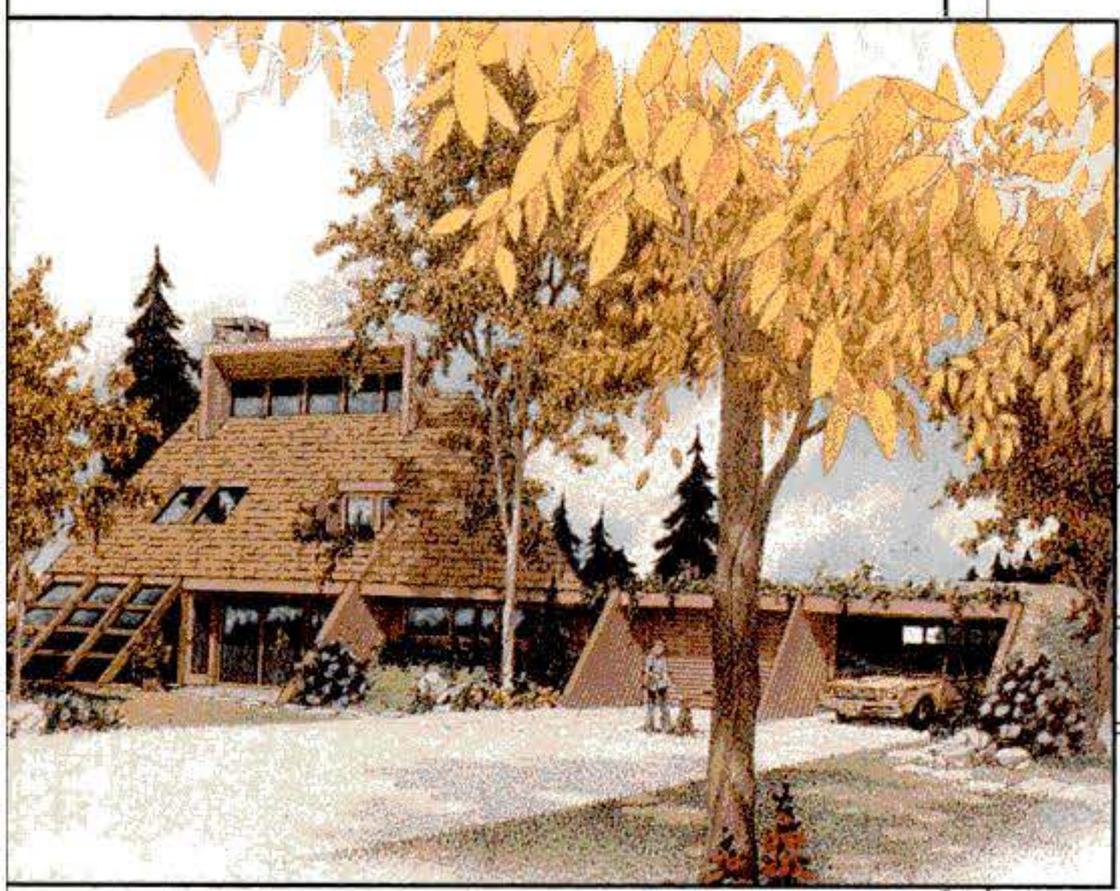
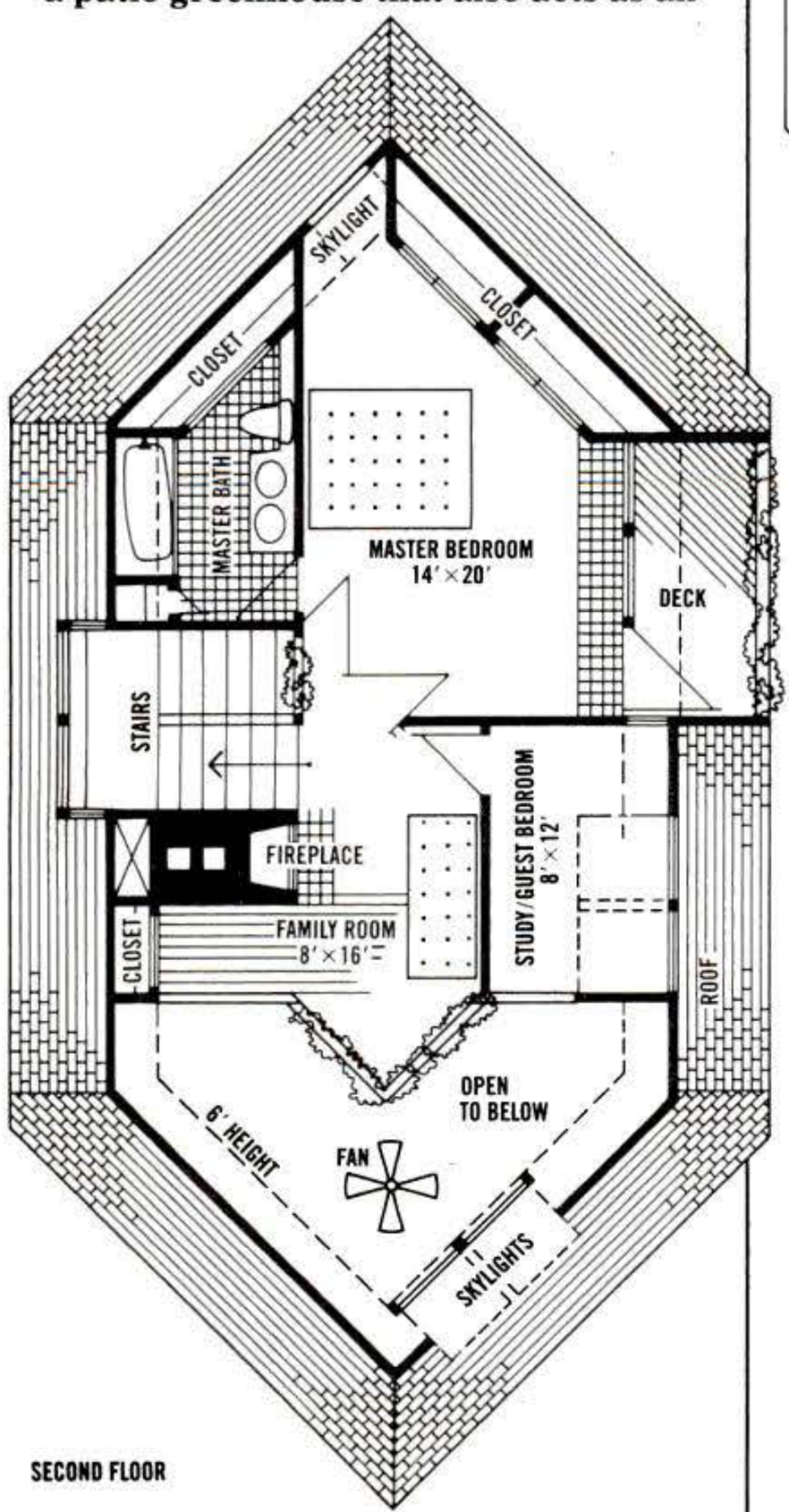
OMEGA HOUSE



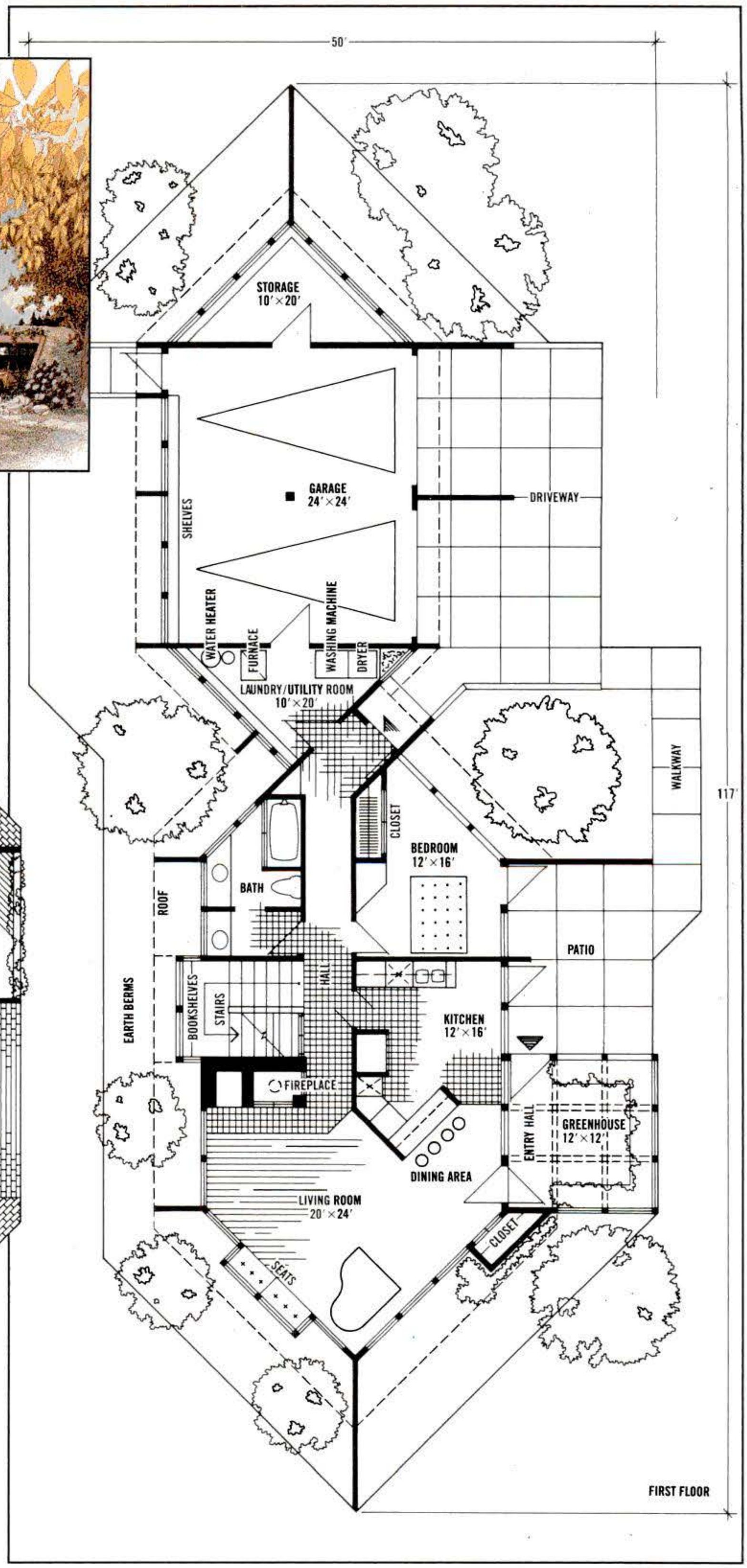
RENDERING BY RANDY PADORR-BLACK

Another Woods design is also bermed along all but its south (entry) wall. It contains 2,500 square feet, including the garage—which can be detached if you prefer. The main entry is through a patio greenhouse that also acts as an



SECOND FLOOR

air lock. High strip windows around the living room prow bring light into this L-shaped area. Both the window seat and a closet are recessed into the berm. An upper story (floor plan above) creates a master-bedroom suite.



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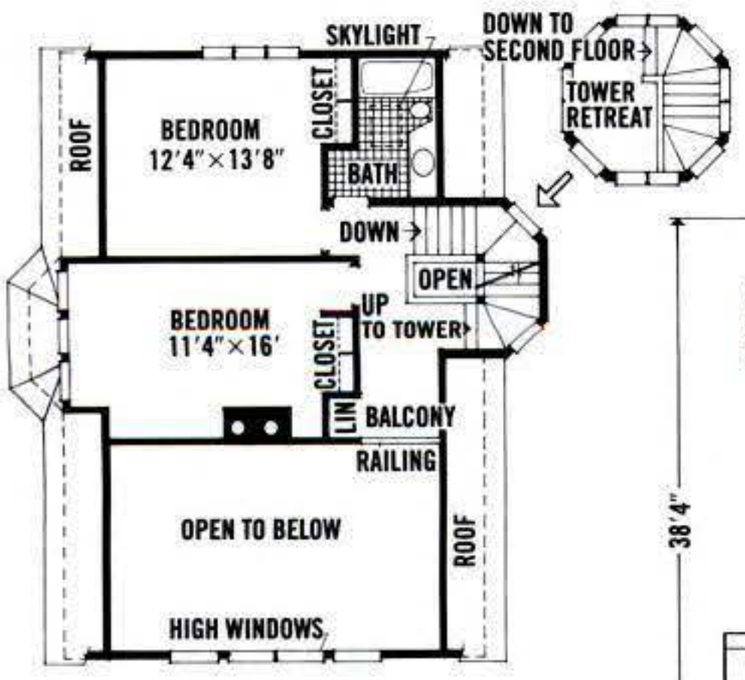
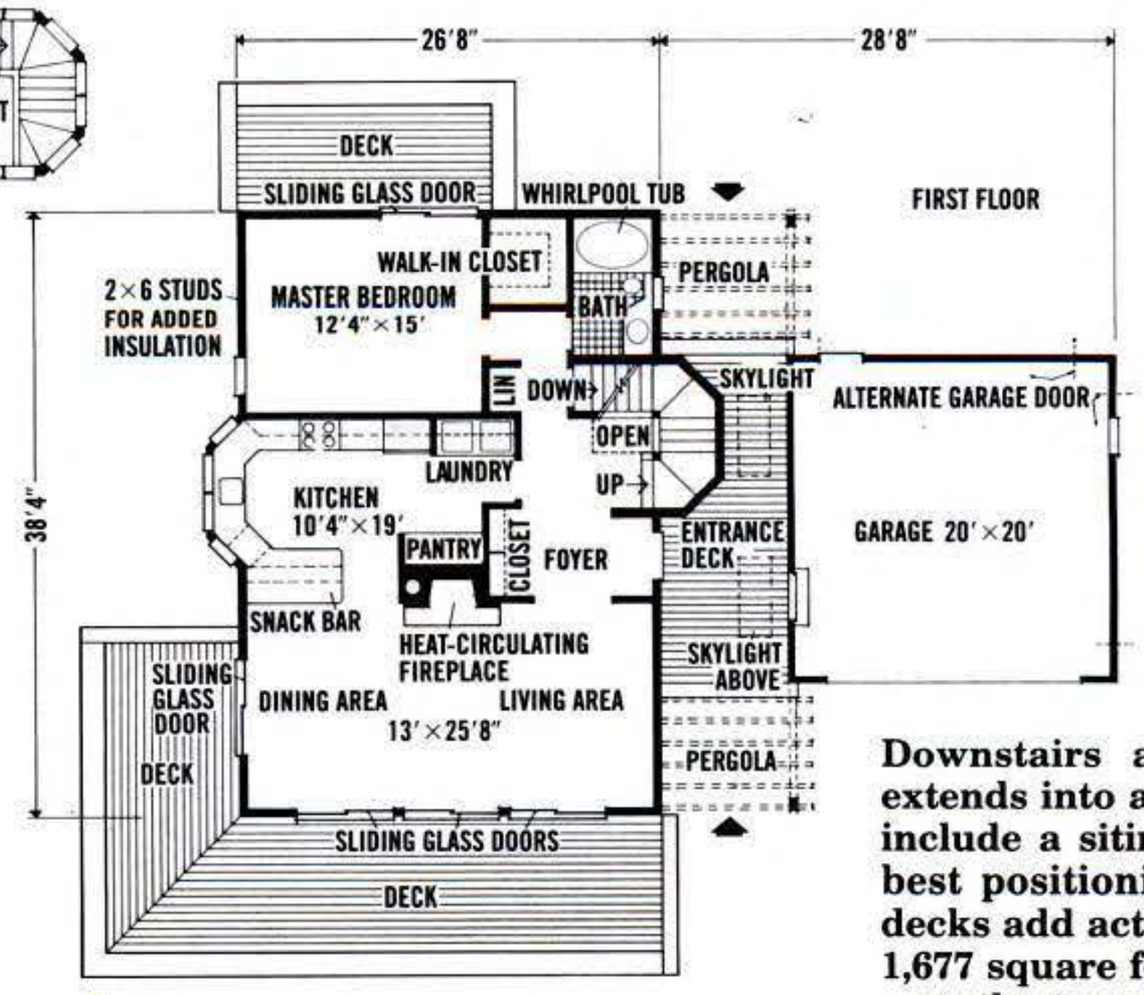


SECOND FLOOR



TOWER BARN RETREAT

Though influenced by old barns, this house uses its gambrel roof to tuck in a partial second story with extra bedrooms and a bath—plus a balcony that shares the spectacular view that the two-story living/dining room has through the glazed end wall. Turn from the balcony and climb another story up the octagonal tower to a unique retreat. Downstairs a large country kitchen extends into a bay window. The plans include a siting diagram to show the best positioning for any plot. Three decks add activity areas to the home's 1,677 square feet (not counting garage —or the tower retreat).

HOW TO ORDER HOUSE PLANS

- Atrium house plans are $125 per set, $175 for four sets, from Alfredo De Vido Assoc. (699 Madison Ave., New York, N.Y. 10021).
- Detailed construction plans for the Radiant and Omega can be ordered from Charles G. Woods (Natural Architecture, RD 3, Box 538, Honesdale, Pa. 18431), for $150 per set. A set for both houses: $275. Additional sets of the same plan are $25 each. Phone (717) 253-5452 for Visa or MasterCard orders.
- A set of four Two-Story Prow plans is $225 (with daylight basement) or $200 (without). Mirror reverse plans are available, as is a materials list ($30 extra). Write Kenneth Gephart AIBD/CSI, 9630 S. W. Eagle La., Beaverton, Ore. 97005. Phone (503) 641-7584 for Visa or MasterCard orders.
- The adaptable earth shelter house is available as one set of plans for $100, showing both north- and south-entry versions. Send payment to Malcolm Wells, Box 1149, Brewster, Mass. 02631.
- Tower Barn plans are $150 per set; five sets $195. Mirror reverse plan is $15 extra; materials list: $30. Homes for Living, 363 Seventh Ave., New York, N.Y. 10001.

Please add $10 handling and shipping to all orders sent to U.S. addresses. Canadian and overseas orders are subject to added costs.

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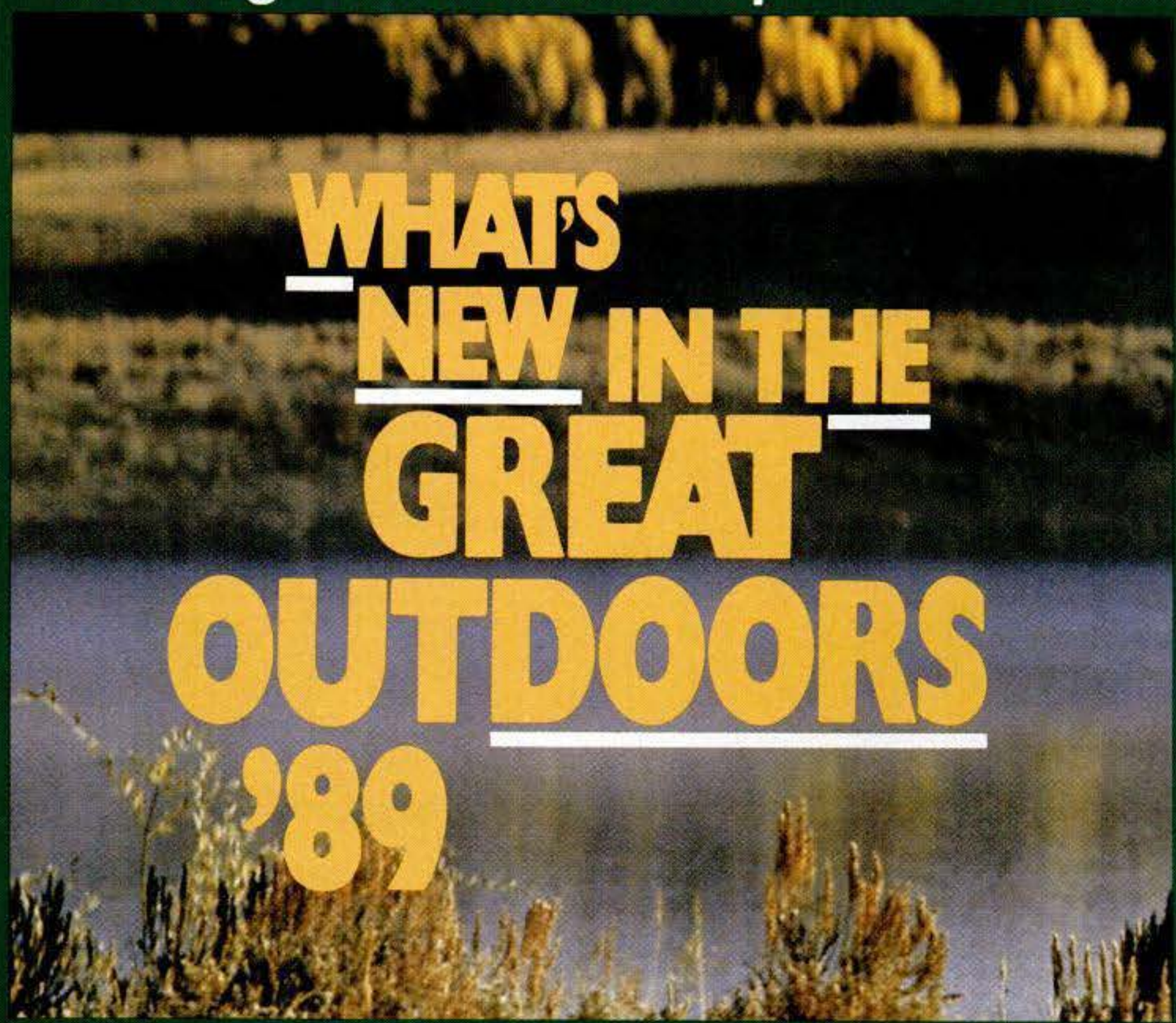

A special section on camping, boating, fishing plus other recreational vacation features.

Watch for it!

Neo Geo

The small oval badge—a globe with the familiar Chevrolet bow tie at the center—attached to the grille of a 1990 Geo Prizm as it emerges from the assembly line signifies a teaming up between Chevrolet and some of the world's best auto makers.

The American-built Prizm rounds out the Geo line, which includes the Suzuki-made Metro mini-car, the Isuzu-made Spectrum economy hatchback and sedan, and the Tracker sport-utility vehicle, which is produced by Suzuki in Canada.

The front-wheel-drive Geo Prizms, which replace the Chevrolet Nova, are built alongside Toyota Corollas at the New United Motor Manufacturing plant, a joint venture between General Motors and Toyota. The Fremont, Calif., assembly plant was closed in the mid-1980s because of low-quality construction and labor strife. But now it has a new life as a builder of economy cars.

The Prizm is powered by a Toyota-manufactured 102-horsepower 1.6-liter four-cylinder engine with multi-port fuel injection. (The base Corolla in contrast gets by with a carburetor and 12 hp less, although higher-horsepower engines are available.) The engine has belt-driven double-overhead camshafts, and there are four valves per cylinder arranged to form an efficient combustion chamber with centrally located spark plugs. This level of engine sophistication is unexpected in an economy car, but the proof is in the Prizm's performance.

The Prizm is peppy around town, with a 0-to-60-mph time of about 10 seconds with the five-speed manual transmission, says Geo. The MacPherson-strut independent suspension and isolated subframes make for smooth and quiet driving even on less than ideal roads, and the chassis is reinforced for extra rigidity. But the car's power steering fails to transmit enough road information to the driver.

The Prizm is available as either a four-door notchback or a five-door hatchback, with 12 and 32.2 cubic feet of cargo space, respectively. Both offer fresh, space-efficient styling along with high-quality construction and finish.

While I was touring the Fremont facility, an engineer told me that before GM closed the plant, vehicles coming off the line averaged 40 defects that needed repair before the cars could be shipped to dealers. Now, he said, they average one to two defects per car. —*Brian Nadel*

The Prizm hatchback is powered by the same sophisticated 1.6-liter engine as the notchback, but offers nearly three times as much cargo space.

The Geo Prizm four-door notchback, which is built in Fremont, Calif., is a variant of the Toyota Corolla.

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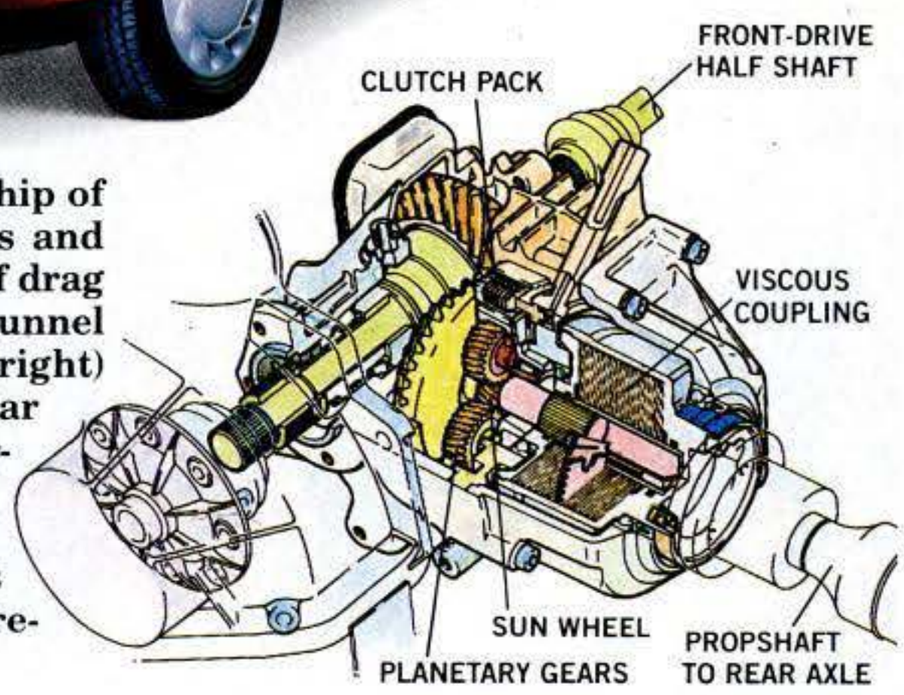

The Opel Vectra 4×4 is the flagship of a 22-model family of notchbacks and hatchbacks. The 0.29 coefficient of drag was honed by extensive wind-tunnel testing. The viscous coupling (right) varies the torque split front-to-rear from 80:20 on a dry good road surface to 40:60 on gravel for the best grip. An electronically controlled clutch pack disengages the rear-drive on braking to preserve the anti-lock feature.

CANNES, FRANCE

Barreling over the crest of a hill on a dirt road in the south of France, the front wheels of the four-wheel-drive Opel Vectra sedan I was driving began to lose grip with the road. Instantly, the Vectra's innovative all-wheel-drive system applied more engine torque to the rear wheels, and I drove smoothly away. Later, when I stabbed the brake pedal on an equally treacherous road, the rear-drive disengaged so the anti-lock brakes could safely stop the car.

Maximum traction under most road conditions and the availability of anti-lock brakes are but two appealing features of the new Opel Vectra 4×4 from General Motors' German subsidiary. I recently tested a Vectra through 150 miles of tortile country roads and was impressed with the car's road-holding ability.

Vectra has a full-time four-wheel-drive system that continuously adjusts to changing road conditions without any driver intervention. A viscous coupling in the differential automatically controls the division of torque between the front and rear wheels for maximum road contact and traction. For instance, from a start on a dry road, all power goes to drive the front wheels, but as weight is transferred to the back of the car, 20 percent of engine torque is diverted to the rear wheels for smoother acceleration. This avoids the front-wheel spin and rocking under power that are common to front-drive cars when they are rapidly accelerated.

As you shift through the gears in the Vectra, the rear axle gets an increasing share of engine torque: Actual split depends on road conditions, load, and possible loss of traction. While driving on a good-quality paved road the differential divides 80 percent of the engine's torque to the front and 20 percent to the rear. But on a loose gravel or dirt road the torque split changes to 40 percent front and 60 percent rear.

Power to match the car's exceptional grip is offered in a transversely mounted four-valve-per-cylinder twin-cam two-liter engine that develops 150 horsepower with a catalytic converter. The free-flowing power comes from a two-stage throttle-body assembly that gives high gas velocity for lively part-throttle response and deep breathing for full-open-throttle driving.

The Vectra, which takes the Vauxhall Cavalier nameplate in England, has flush wraparound glass and spoilers to control airflow over its slippery 0.29-coefficient-of-drag body.

While it is unlikely that the Vectra will be imported to the United States, selected components and styling may eventually be shipped across the Atlantic.—*David Scott*

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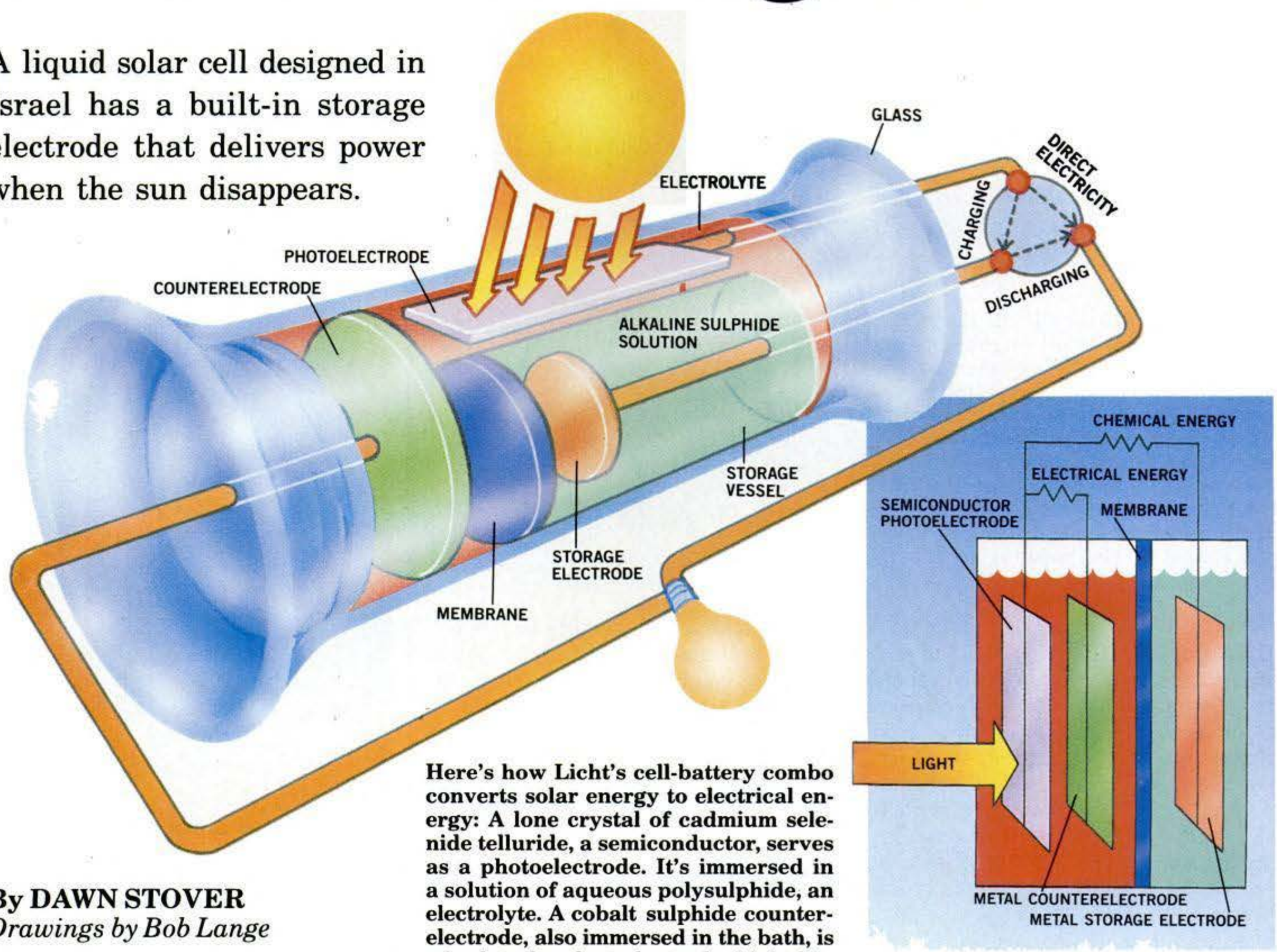
Solar cell that works nights

A liquid solar cell designed in Israel has a built-in storage electrode that delivers power when the sun disappears.



Here's how Licht's cell-battery combo converts solar energy to electrical energy: A lone crystal of cadmium selenide telluride, a semiconductor, serves as a photoelectrode. It's immersed in a solution of aqueous polysulphide, an electrolyte. A cobalt sulphide counterelectrode, also immersed in the bath, is wired to the photoelectrode. Light hitting the photoelectrode excites electrons, which then jump from the electrolyte. They travel from the photoelectrode to the counterelectrode, powering an electrical device placed along the wire connecting the two electrodes. Upon reaching the counterelectrode, the electrons return to the electrolyte, completing the circuit.

In Licht's device solar energy also drives a chemical reaction to stockpile chemical energy. While the sun is shining some electrons are diverted from the main circuit down a second wire to a tin-sulphide storage electrode. There the electrons split the tin sulphide molecules, leaving tin on the electrode and releasing sulphide into an alkaline sulphide solution. When the light becomes too dim and electrons stop arriving at the storage electrode, the tin and sulphide recombine, releasing electrons that rejoin the main circuit and deliver power.

By DAWN STOVER
Drawings by Bob Lange

"One of the biggest problems with solar energy is its intermittent nature," says Dr. Stuart Licht, a chemistry professor at Clark University in Worcester, Mass. "It's not useful to a normal household."

While at the Weizmann Institute of Science in Rehovot, Israel, Licht and a group of researchers came up with a solution: a device that captures *and stores* solar energy. It discharges electricity in the dark.

Shortly after liquid solar cells containing conductive chemical baths were invented in the late 1970s, the Weizmann team suggested these cells could incorporate storage batteries. "We already had an electrochemical system," says Licht. "And a battery is also an electrochemical system."

Other solar researchers, trained in solid-state physics, hadn't figured out how to prevent light-induced rusting. "I approached the problem purely as a chemist," Licht says. Instead of looking for protective coatings, he sought chemically compatible materials that would react in constructive ways—circumventing more destructive pathways.

The cell-battery system's overall efficiency is 11.3 percent, slightly better than a photovoltaic cell combined with an external battery.

Licht is now experimenting with inexpensive thin-film photoelectrodes. If its efficiency can be improved, a thin-film system could provide round-the-clock energy for remote areas. PS

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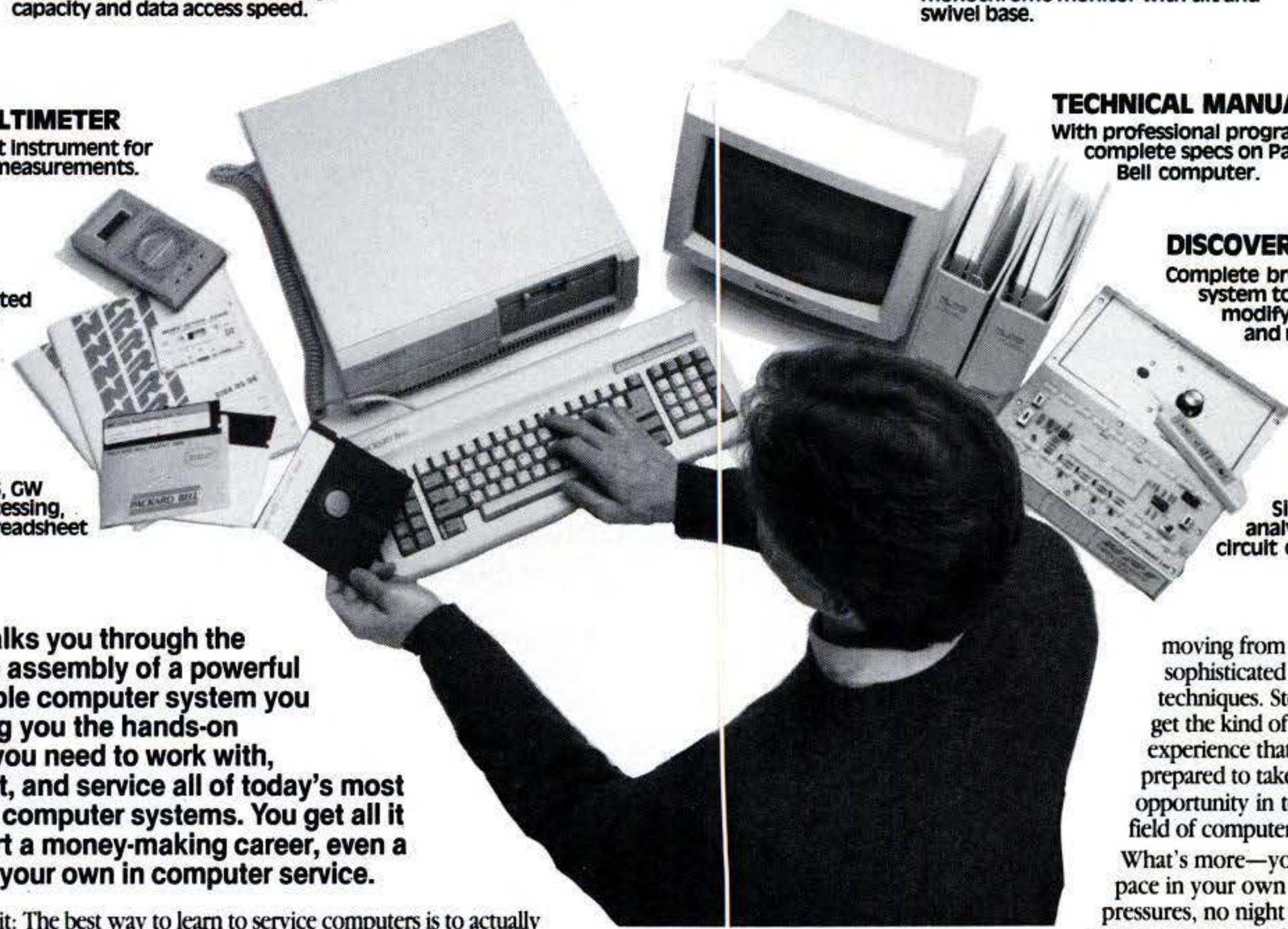

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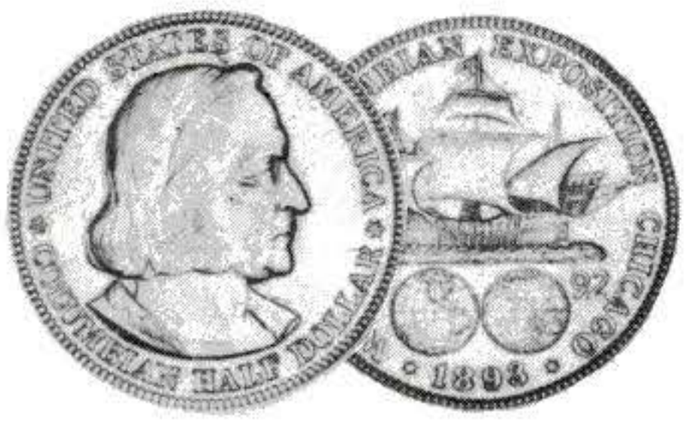

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Cordless phones

[Continued from page 113]

uses *your* base (which is attached to *your* phone line) to make *his* long-distance calls. Fortunately, pirating has been eliminated by a digital security system incorporated into most new cordless phones.

"Every time the handset is returned to the base a new security code is accessed randomly," says Donna Cifelli, AT&T product manager. "Only that code can marry the handset to the base for calling."

When the handset signals the base for a dial tone, it also sends the coded signal. If the codes don't match—almost a certainty if someone is using another handset—the base unit won't send a dial tone. The AT&T system holds about 64,000 codes, making the odds 64,000 to 1 that someone else could use your base. Not enough? Panasonic has up to 256,000. Sony has one million codes stored in several of its models.

Who's there?

Despite those odds that somebody could use your phone illegally, the possibility of someone listening in —eavesdropping—on your conversation is incredibly good.

"Ninety-nine percent of the populace aren't aware that people can listen to their conversations," says Jeff Cantwell, Southwestern Bell Freedom Phone product manager. Like a CB radio, your cordless phone uses one of 10 channels that is shared by others. If someone nearby is using a phone on the same channel, you can hear his conversation and he can hear yours. (To find a clear channel to use, most of the new cordless phones automatically scan across all 10 channels until they find an empty one, or they allow you to switch manually through several channels.)

To prevent eavesdropping, Southwestern Bell has developed a microprocessor for signal scrambling. "The chip takes a second of transmission and breaks it up into about twenty segments," explains Cantwell. "It mixes them up at one end and puts them back together at the other. Anyone listening in will hear garbled sounds."

High-quality communications. Lots of use between battery charges. Anti-pirating and private operation. What else do the new portable phones need? "Features," says AT&T's Cifelli, "the basic features you've come to expect from a standard phone."

They're coming. Manufacturers of portable phones have begun to add last-number redial, speed dialing, and even a speaker phone. Does all that really make a difference? As I pace from my den to the bedroom and continue my conversation, I have to admit: It all sounds good to me. PS

Artificial gill

[Continued from page 123]

break their bonds to oxygen. Over time, a number of these high-affinity duds piled up on the lab shelves.

Steven J. Carnevale, vice president of the company and an avid scuba diver, remembers attending a conference at which food packagers were complaining about spoilage caused by oxygen, and discussing possible solutions. "I felt like standing up and saying, 'Hey, we've got it!' " he recalls. By that time, researchers at Aquanautics had decided the rejected chemicals could make foods and beverages last longer. And they had given their oxygen-scavenging chemicals a new name: Longlife.

Better-tasting beer

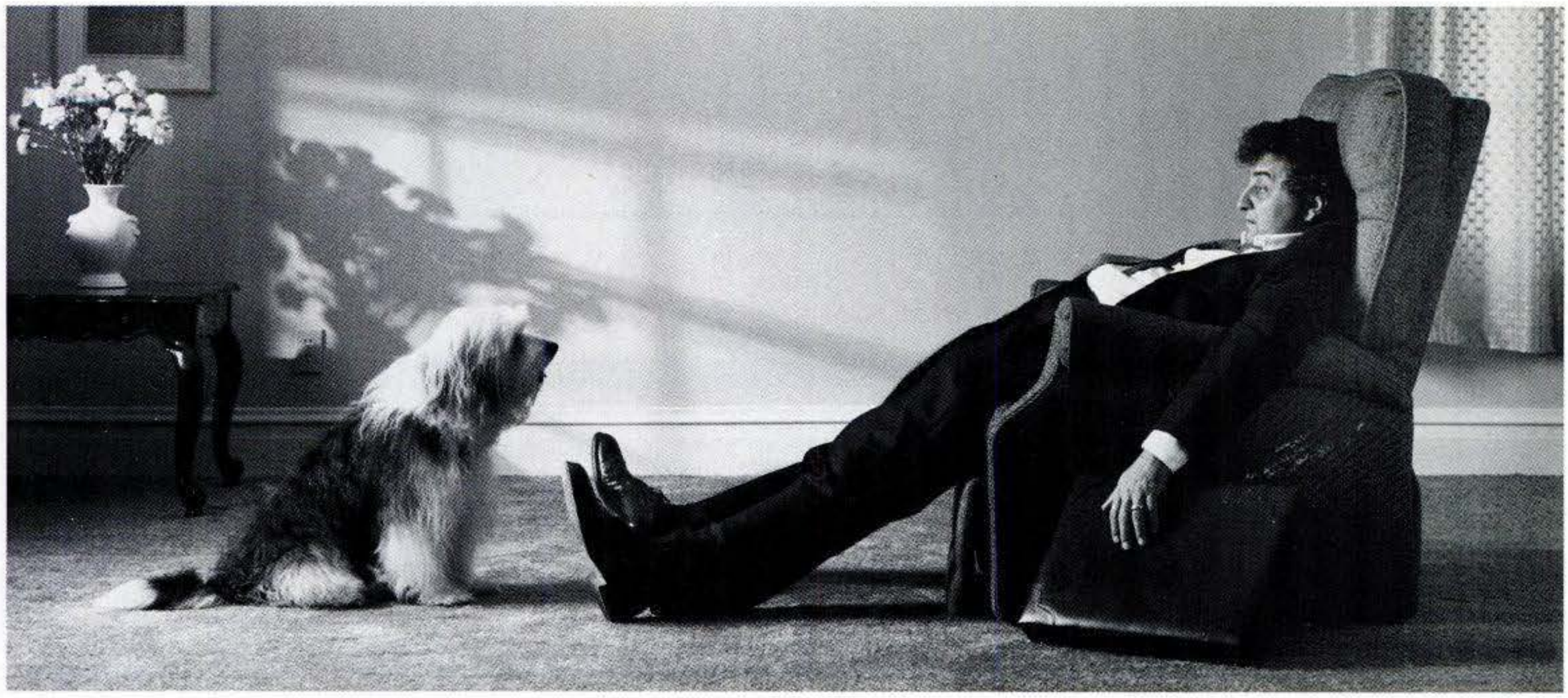
One product that's extremely oxygen sensitive is beer. After a few months beer loses its crispness, and connoisseurs describe it as "skunky." That's why it's bottled in glass—plastic is too "leaky." Knowing this, the researchers found a way to attach oxygen scavengers to solid materials, like silica. The sandy compound sucks oxygen out of beer. "You can filter the scavenger out of the solution afterward," says Zenner.

Water, or a cup of coffee, contains oxygen in concentrations of about 8,000 parts per billion (ppb). That would ruin beer, so brewers go to great lengths to reduce the oxygen to between 250 and 400 ppb before bottling. But they'd like it to be even lower. "We can take it down to ten to fifty parts per billion," claims Zenner.

Another idea is to remove oxygen after bottling—by putting the scavenger in a submerged pouch or by incorporating it into the bottle cap. "Let's say you want to keep all the oxygen out of some Ocean Spray cranberry juice," proposes Buckenham. "The cap that you put on could have a liner that's made up of this [oxygen-absorbing] material." It may even be possible to attach oxygen scavengers to plastic packaging. Aquanautics has already experimented with methods of linking Longlife and polymers.

Experimental molecules that were rejected because their oxygen affinity was too feeble may prove useful too. They might facilitate oxygen transport through a membrane—in contact lenses, for example. (One problem: the carriers aren't transparent. "Good sunglasses!" says Zenner.)

Some day, the gill technology may even be viable for its original purpose—scuba diving. "Man has always wanted to fly like a bird and swim like a fish, and the Wright brothers taught us how to fly," Buckenham says. If the gill technology evolves the way aviation has, he says, "then maybe ten years from now there'll be a Boeing 747 equivalent underwater." PS



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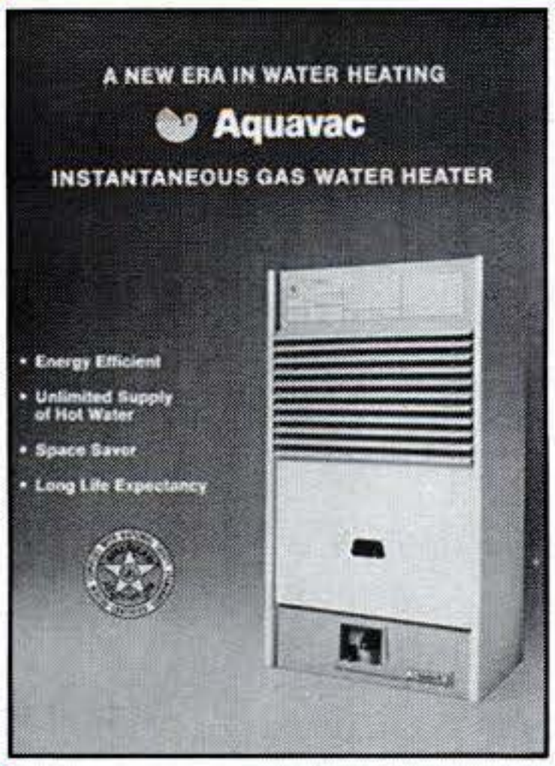

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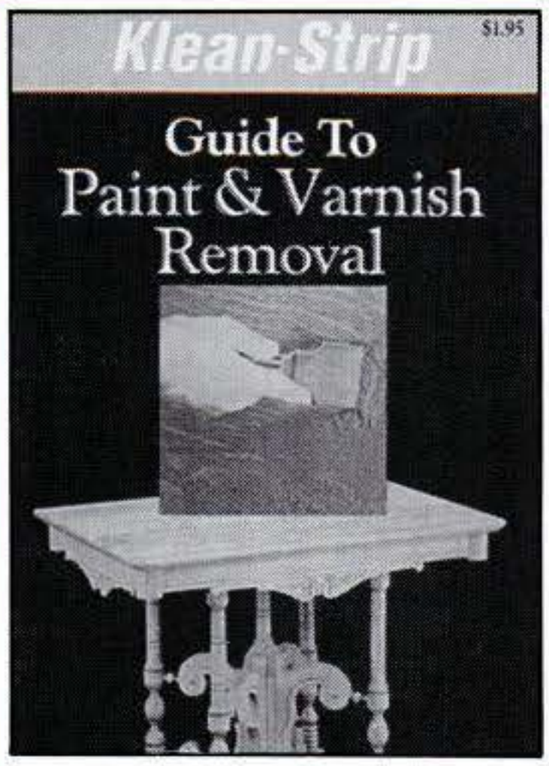

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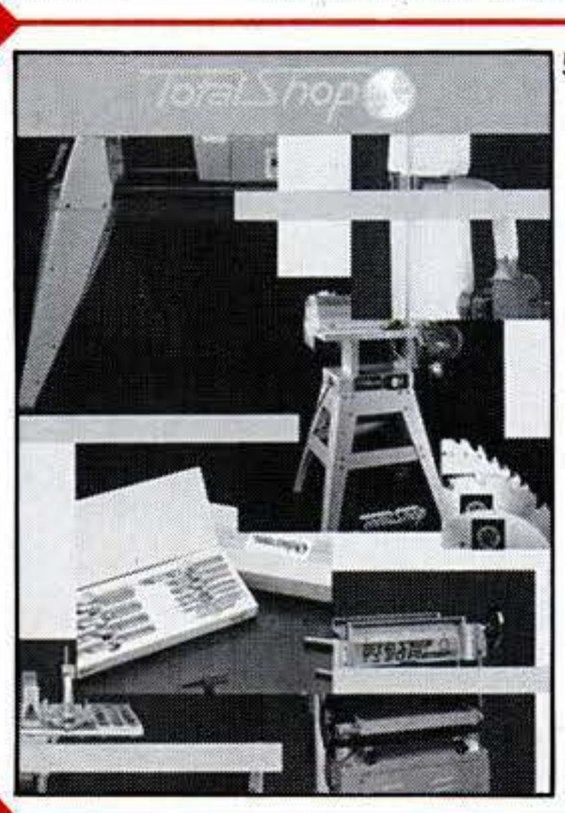

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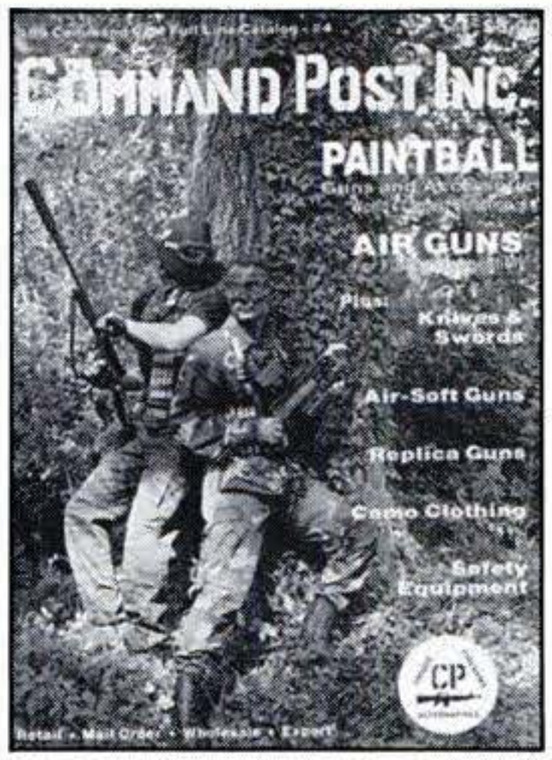

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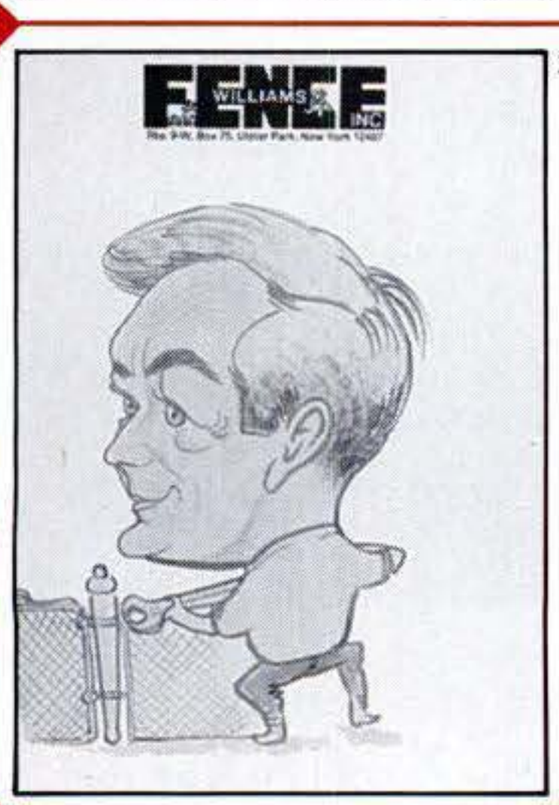

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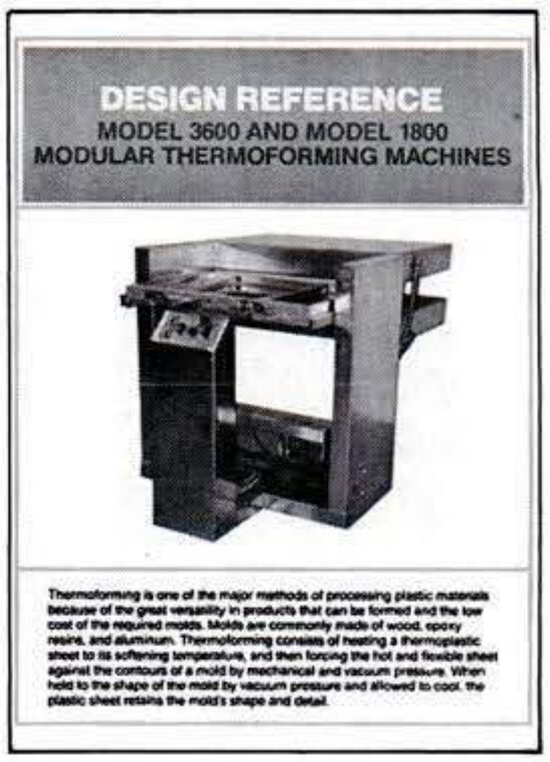

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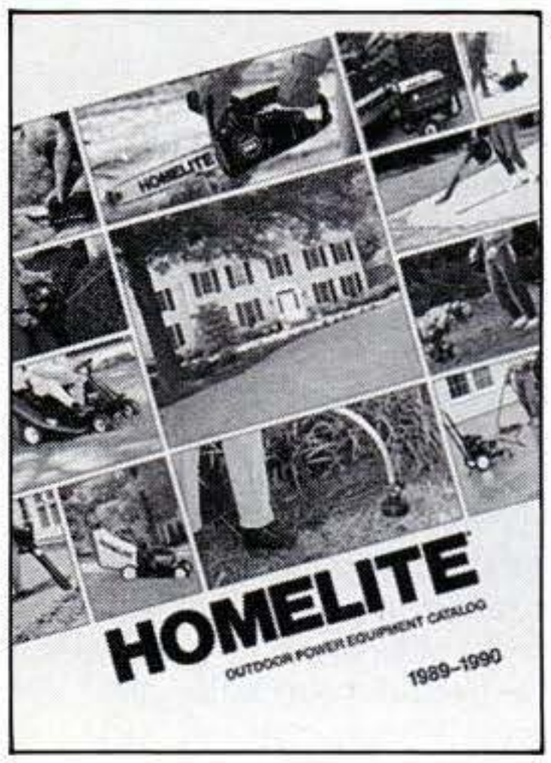

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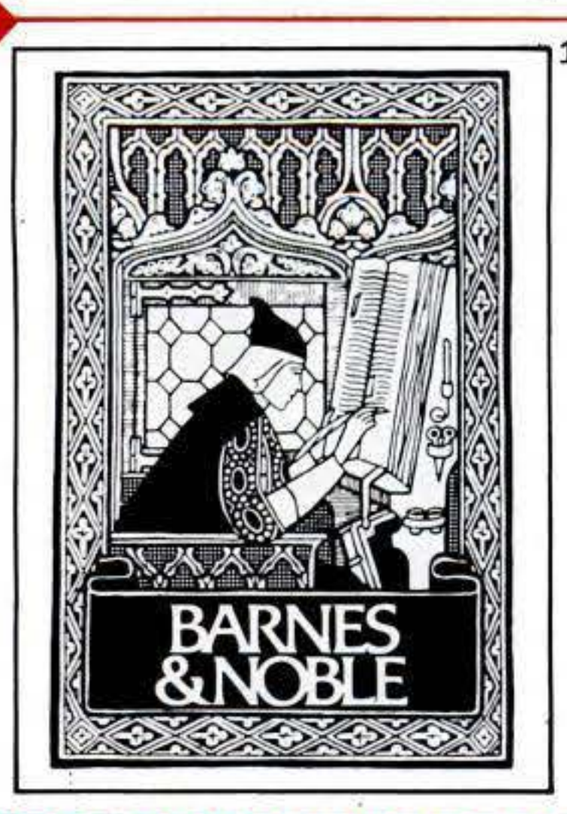

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Quiet diesel

[Continued from page 111]

ings in skeletal carriers, and doesn't incorporate a conventional crankcase. This construction eliminates head distortion and gasket problems, adds rigidity for quietness, and saves weight. The iron casting that houses all of the critical moving parts is then completely shrouded in a pair of aluminum die castings. These enclose the lower "wet" section of the engine.

While *indirect* fuel injection is used on most diesel engines for cars because it makes relatively little noise, the Austrian design uses *direct* injection. Directly injecting fuel into the cylinders has long been known to boost efficiency, but it has traditionally been accompanied by clattering combustion knock caused by the sudden rise in cylinder pressure.

Steyr cleverly beats this with two-stage fuel injection; a small dribble of fuel precedes the main charge to slow and thereby hush the combustion process. And instead of the central injection pump found in today's automobile diesels, the Steyr engine has individual unit injectors for each cylinder. Driven by the overhead camshaft, these mechanical assemblies combine an injection nozzle with an individual high-pressure pump that squirts the fuel directly into the cylinder at a vigorous 20,000 psi.

Muscular yet refined

Steyr sees a niche market for its refined car diesels, and is currently trying to find a home for a 3.2-liter six-cylinder version. In turbocharged form with intercooling, this engine cranks out 165 horsepower at a brisk (for a diesel) 4,300 rpm. The company sees it as a rival to the Mercedes-Benz diesels that are popular in West Germany, France, and Italy because of their low fuel costs.

"This engine has been fitted to several European and American cars, including a Cadillac Seville and a Pontiac Firebird, for testing and demonstrations," Egger told me. But a hoped-for Jaguar XJ6 conversion would be the real breakthrough for the Austrians. They figure Jaguar could tap new markets in Europe with a diesel XJ, which could nearly match the performance and driving refinement of the British auto maker's 3.6-liter gasoline-engine car, while delivering whopping savings on the high cost of fuel in Europe and the United Kingdom.

Although enduringly low oil prices keep Steyr from anticipating any diesel-car revival in the near future in the United States, the company is showing American boat builders a 185-hp turbocharged marine version of the diesel six with a water-cooled exhaust manifold. PS

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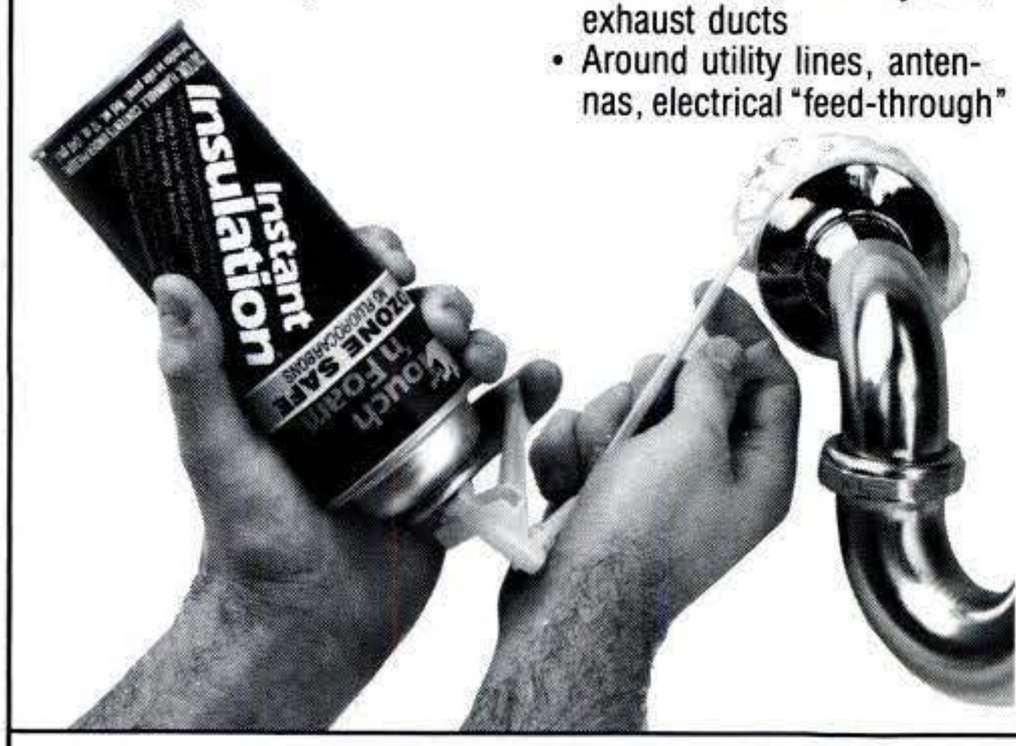

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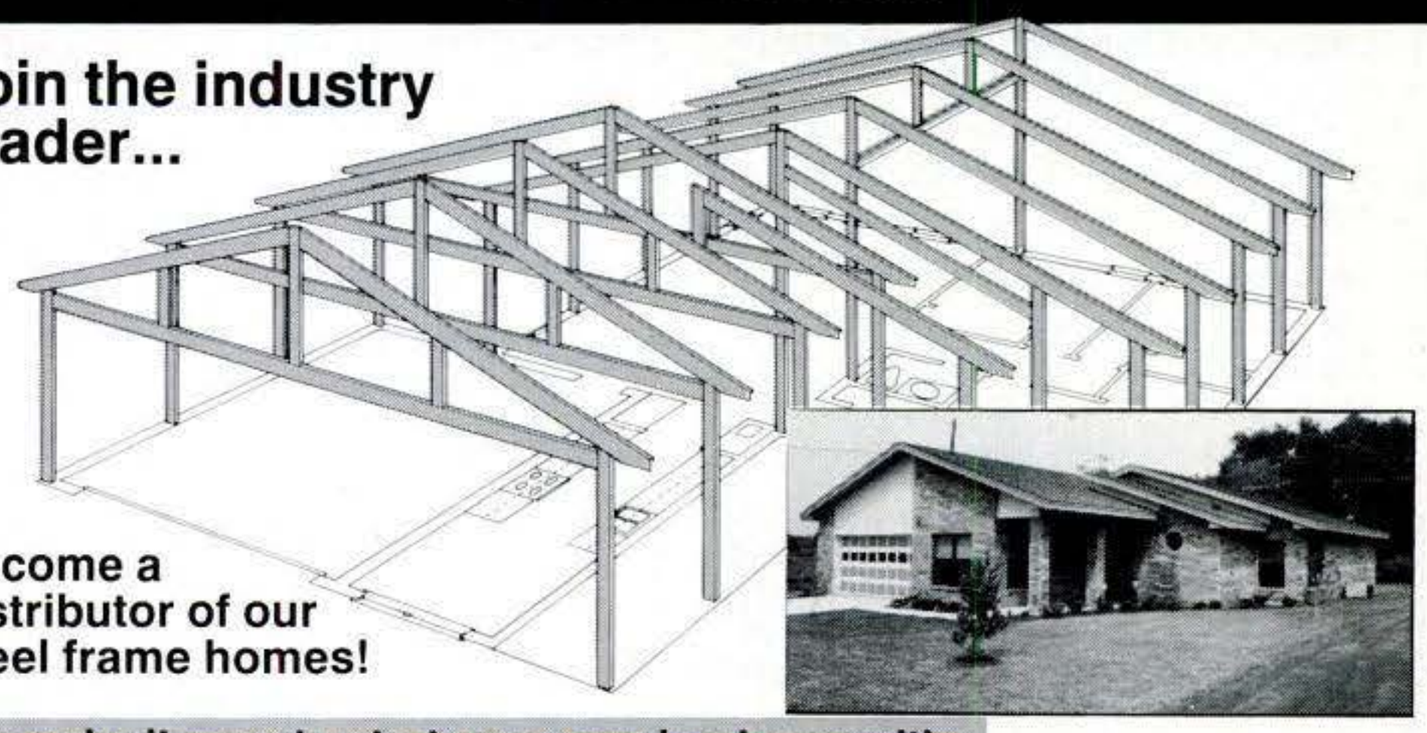

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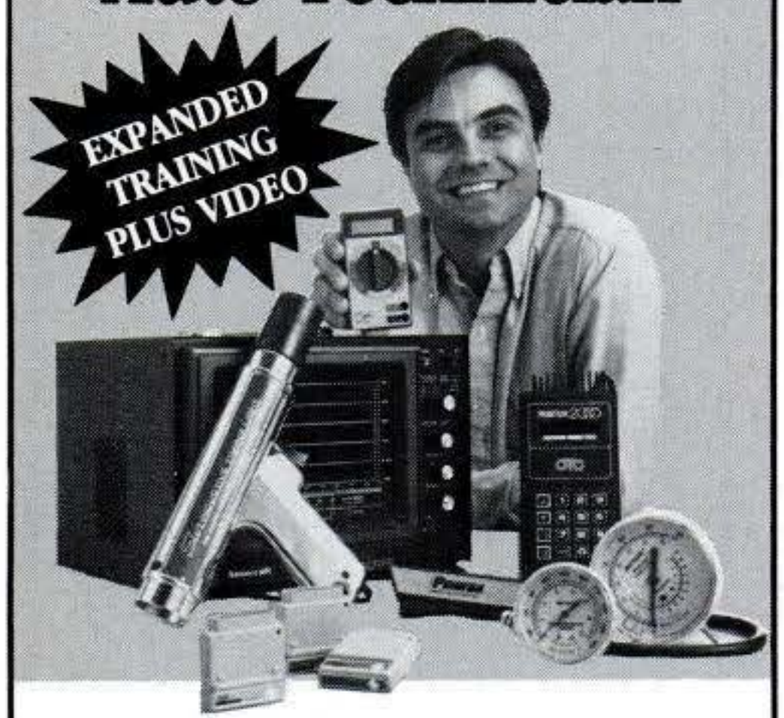

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Super stripper

3M strip-and-finish system is a family of compatible products. Clockwise from top left: semi-paste stripper; hand cleaner; wipe-on poly finish; woven pads of mesh in several grades; the heavy-duty pad, with and without handle; tube of special wood putty for repairs; and sander with continuous-feed roll.

I've just tried 3M's new family of wood-refinishing products that covers every step of the process. And in several cases, the product 3M has developed seems superior to equivalents I've used.

Wood refinishing involves four basic procedures: stripping the old finish down to bare wood; preparing the bare wood by cleaning, smoothing, and repairing surface dents; staining the wood to the desired shade and color; and finishing to seal the stained (or natural) wood for protection.

When 3M's market research showed that over half of the consumers polled expressed dissatisfaction with refinishing products available, the company decided to create a new system, covering all steps right through to cleaning your hands.

The head marcher in this product parade is dubbed Safest Stripper. It pours out looking like white frosting and emits no odors or fumes. Because it is nonflammable and contains no methylene chloride, you can use it indoors and you don't even have to wear protective gloves. The new semi-paste formula lets it cling to vertical surfaces while it works on paints, varnishes, lacquer, and shellac. (Ironically, one of the few things it won't strip is 3M's own finish—toward the end of this product parade.) And it continues to work for up to 30 hours.

You brush a ⅛-inch-thick coat over all surfaces and wait a minimum of 20 minutes (for paint or polyurethane wait at least one to three hours, depending on the number of coats to be stripped). This stripper doesn't bubble, so you must test the area with a putty knife to see when the surface is ready to be scraped. Scrape gently with the knife, and if you don't get down to the bare wood, reapply.

Use one of 3M's heavy-duty woven synthetic pads dampened with stripper to complete the job. Then remove surface residue with the Final Stripping pad dampened with water. Wipe the surface dry with a paper towel, then sand before refinishing.

The stripper comes in pint, quart, and gallon sizes, for $3.79, $6.65, and $20 respectively.

As for the pads—Heavy Duty is roughly equivalent to #2 steel wool. Final Stripping pads are intended to replace #0 wool. Between-Coat finishing pads are for smoothing the surface between coats of sealer, stain, or finish; they replace #00 and #000 wool. All pads can be rinsed clean for reuse.

The Scotchgard Wipe-On Poly Finish is toxic and flammable and can be absorbed through the skin, so rubber gloves and safety glasses are recommended. It comes in satin or gloss, in half pints, pints, and quarts. 3M claims that, applied properly, the half-pint bottle (about $5.50) gives the same coverage as a full pint of ordinary polyurethane.—*Al Lees*

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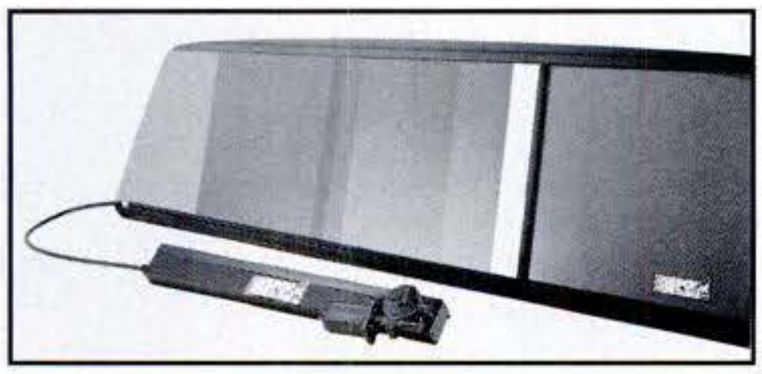

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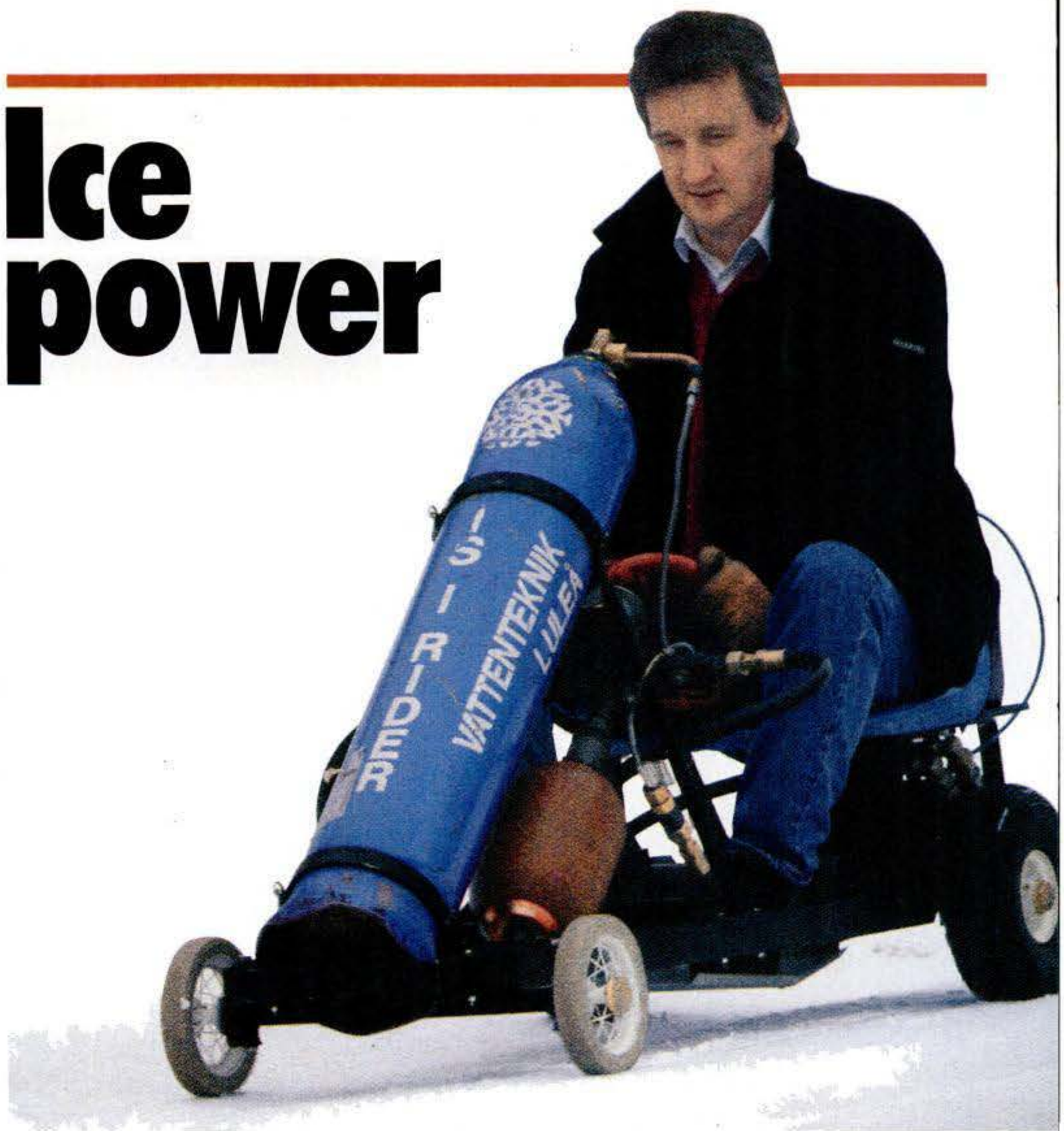
Ice power

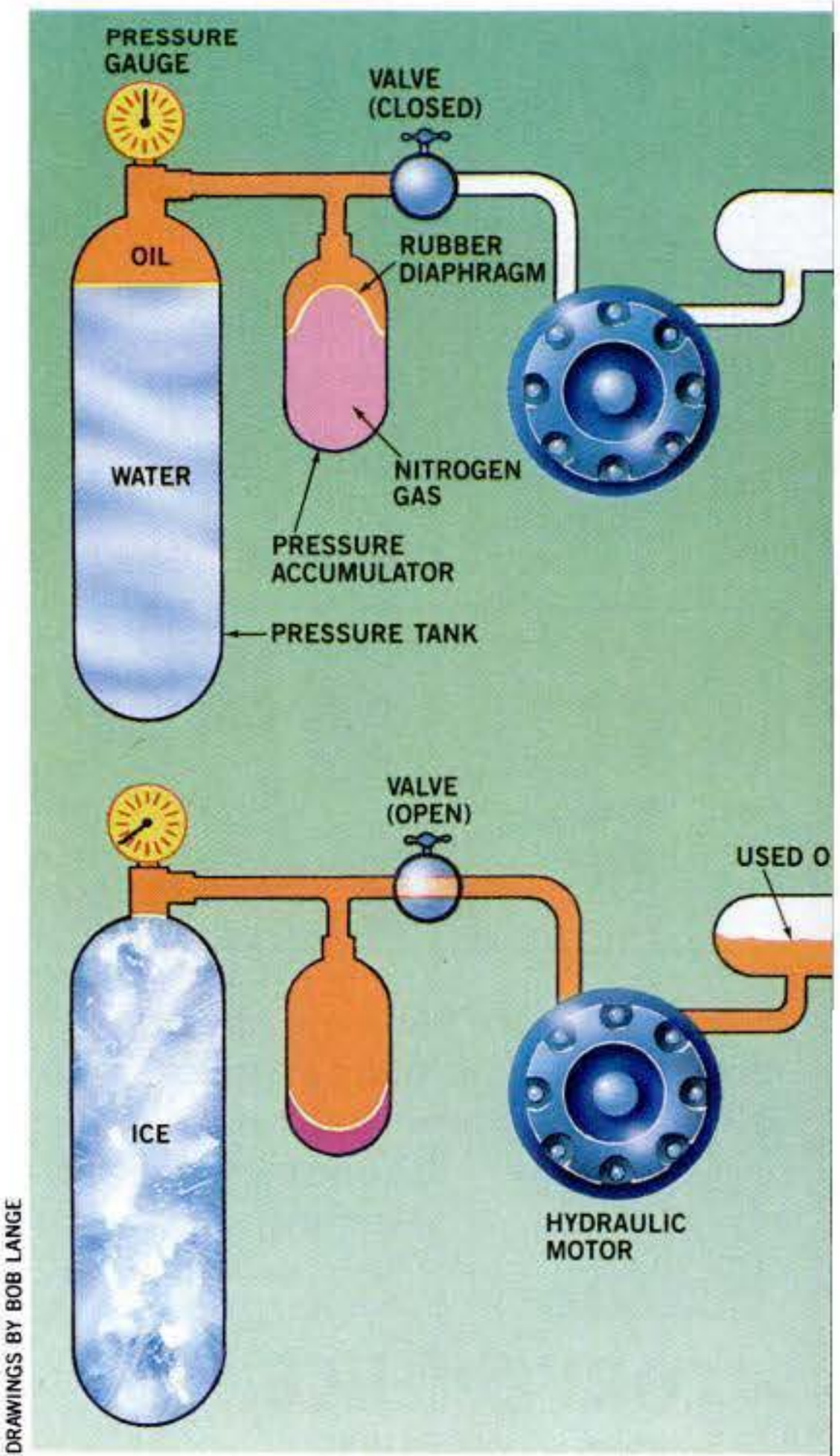


Icy Rider uses a 27-liter oxygen cylinder as a pressure tank. With a stronger tank, the inventor hopes its driving range will increase to several miles.

As freezing water expands, its force can fracture huge rocks and burst steel pipes. To tap this ice power Bo Nordell, a researcher at the Lulea University of Technology in northern Sweden, built a small cartlike vehicle he calls Icy Rider.

Nordell uses a water-filled pressure tank to transfer energy to an accumulator, a small cylinder filled with nitrogen gas. As the water freezes, the accumulator stores the pressurized fluid that powers a hydraulic motor (see drawing). "Leave the cart outside overnight in our Swedish winter, and in the morning I can drive it at fifty miles per hour for a few hundred yards," he told me.

The on-board pressure tank could be left at a base station, charging the storage accumulator between runs. This would halve the present vehicle weight to 130 pounds. Nordell's ice power not only taps a new form of renewable energy, but is silent and nonpolluting.—*David Scott*



Pressure tank is filled with nine-tenths water and one-tenth oil (top). Freezing water expands (right), feeding oil into the accumulator, compressing the nitrogen gas. Valve releases pressurized fluid to drive the hydraulic motor.

DRAWINGS BY BOB LANGE

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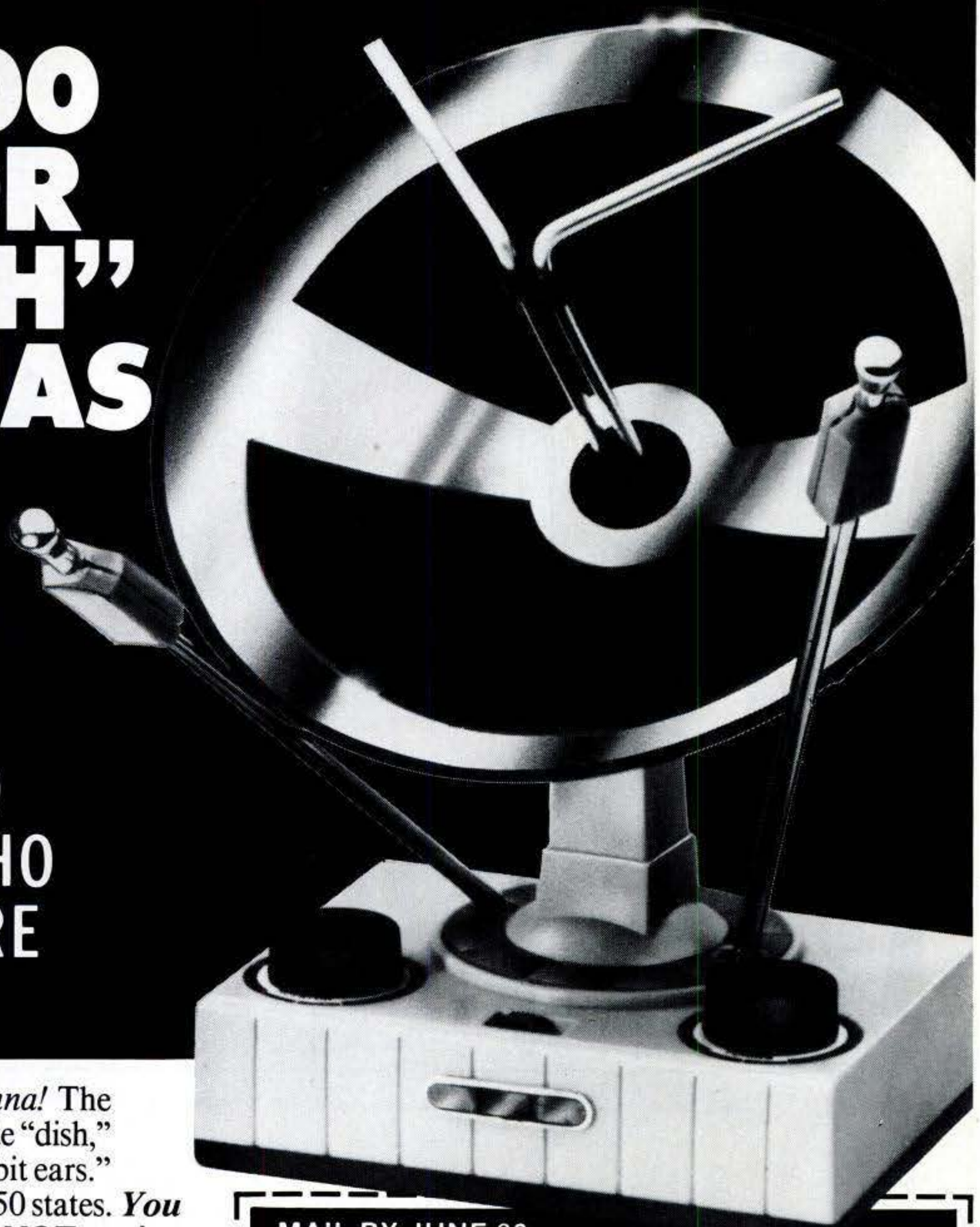

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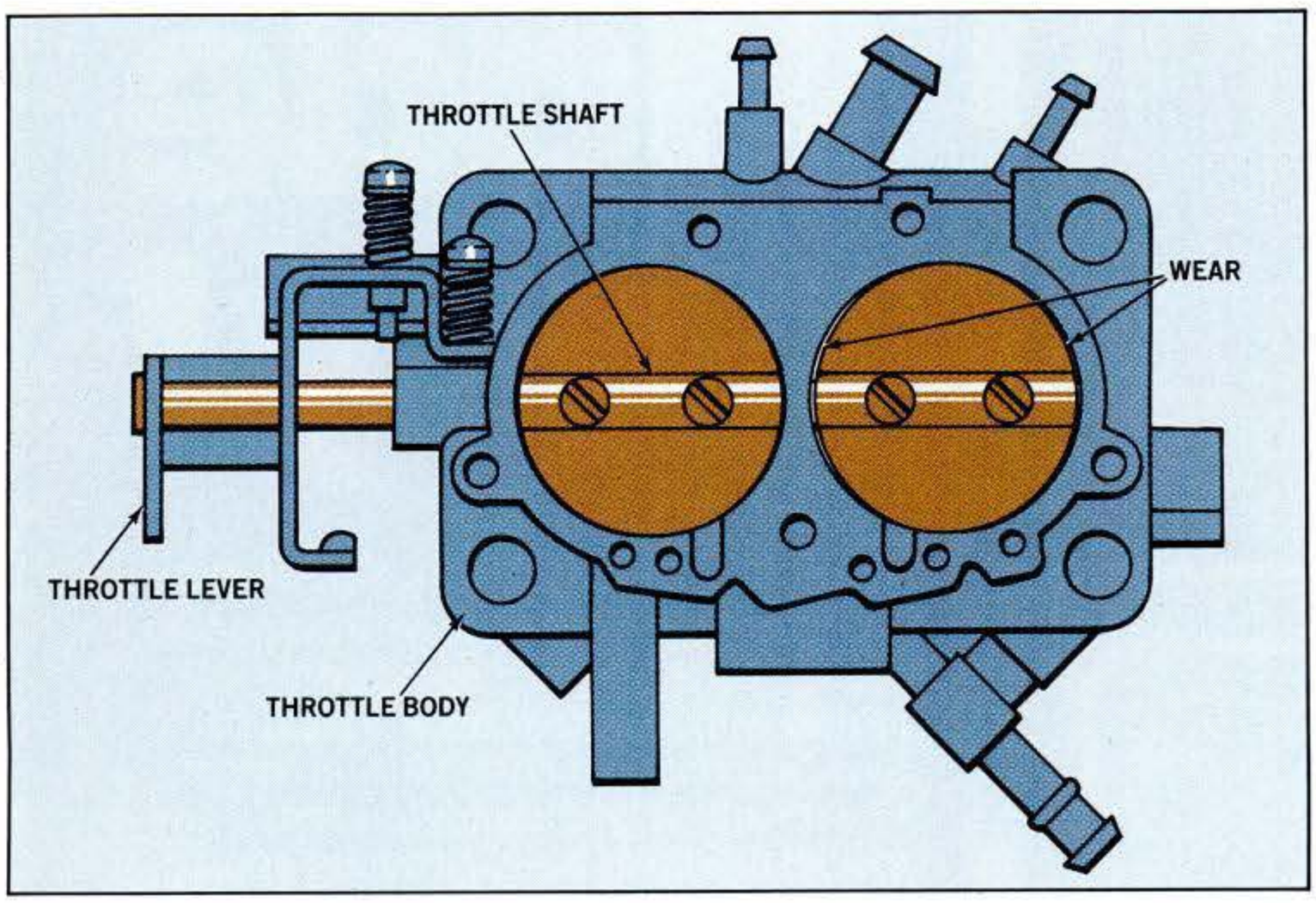
Taking Care of Your Car

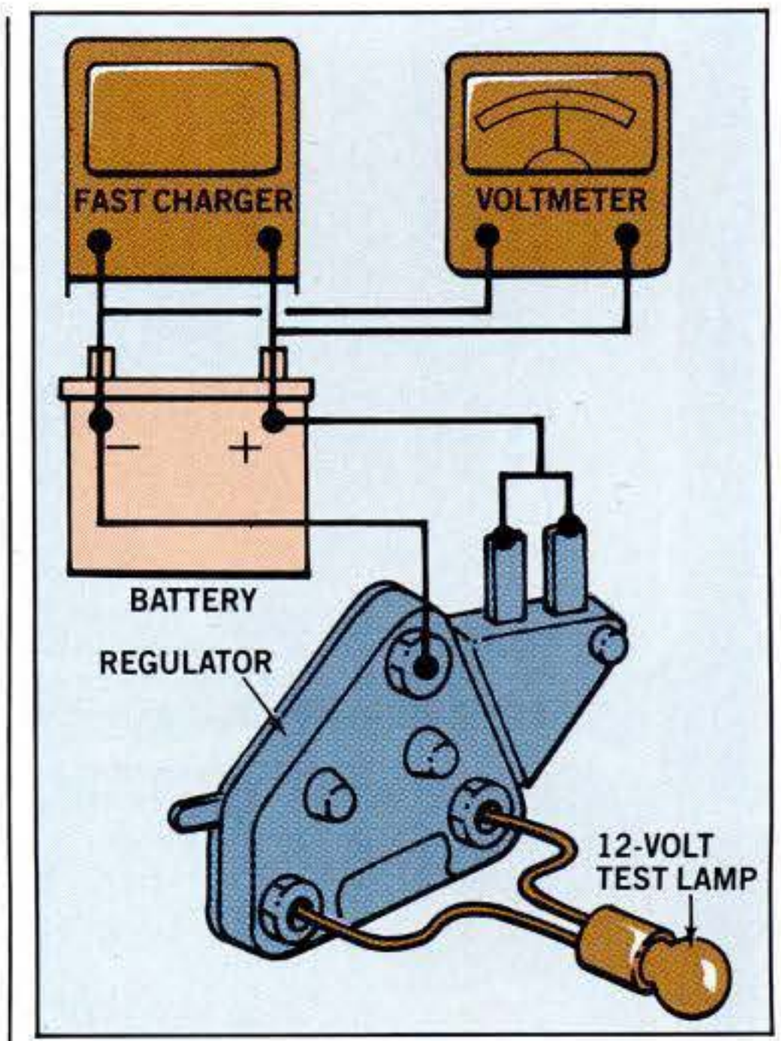
By STEVE MERCALDO

DRAWINGS BY RUSSELL VON SAUERS



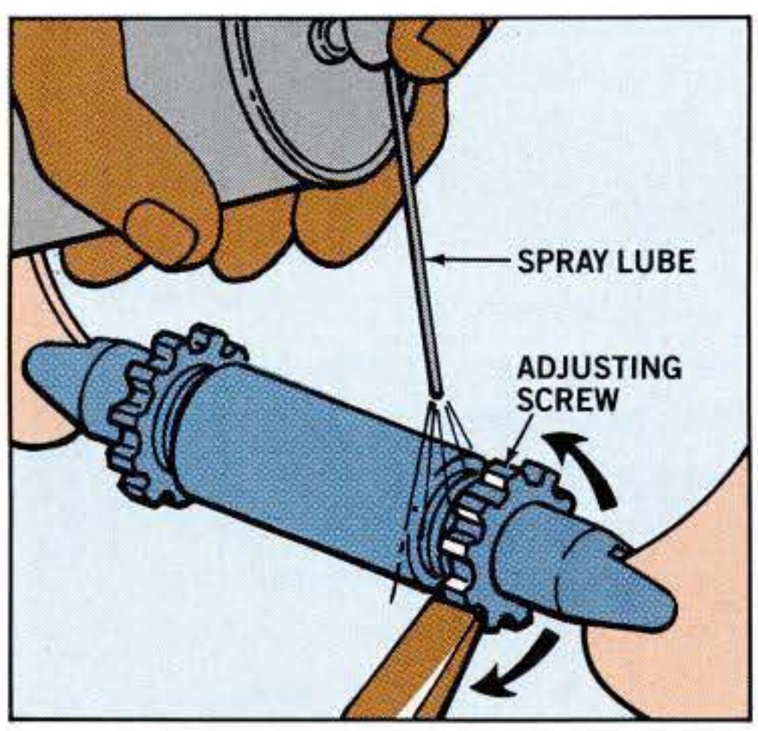
Carburetor cure for the high-idle blues

Does your car's engine run on after the ignition key is turned off, or is there a loud bang when you shift into gear? Abnormally high idle speed could be the cause of these irritating problems. First try to lower the idle speed by backing off the carburetor's idle screw. However, if that doesn't help the situation, check for wear and gaps between the throttle shaft and throttle body. With the engine turned off, grasp the throttle lever and try to move it from side to side. If there is any free play or sloppiness where the throttle shaft meets the throttle body, the throttle body will need to be rebuilt or replaced.



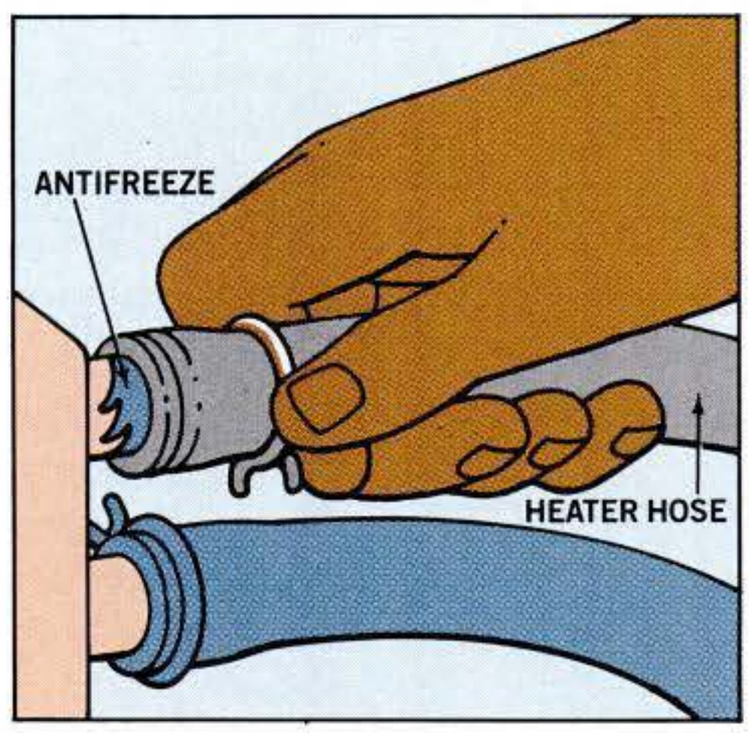
Regulator bench test

To test a General Motors voltage regulator, make the connections shown above. The test lamp will light when connections are made. Slowly increase the charge rate on the battery fast charger while observing the voltmeter and test light. The light should go off between 13.5 and 16 volts.



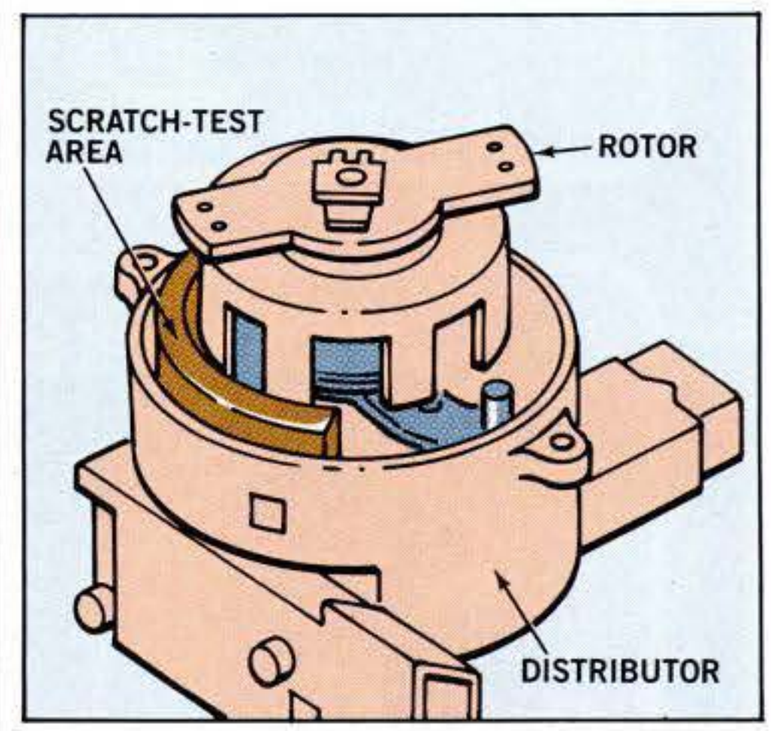
Adjuster lube

The cause of excessive brake-pedal travel can often be a rear brake drum with a jammed self-adjuster. Rust, corrosion, and dirt can work their way in and bind the self-adjuster's screw threads. To free the self-adjuster, spray a liquid lubricant into the end of the screw adjuster while turning it to work the lubricant into the threads.



Heater-hose hint

If you have trouble inserting a heater hose onto the heater core pipe, try spreading a little antifreeze on the mating surface. The antifreeze will act like a lubricant, allowing the hose to slide easily over the pipe. This will not only save both time and effort, it will also protect the fragile heater core from damage.



Ford-ignition fix

A mid-1980s Ford engine that stalls, misfires, or will not start might have a faulty distributor Profile Ignition Pickup (PIP) on its distributor. To test the PIP, remove the distributor cap and scratch the PIP housing with your fingernail. If the black cover material is soft and flakes off, the PIP needs to be replaced.

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Their test data showed a steel on steel 4-ball surface friction of .029 with remarkably low wear. I rushed to my library, grabbed a lubricant handbook to see if my memory was correct. Sure enough! Teflon was listed at .04.

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See NASA Tech Briefs for technical details, 1986, 1987 and 1988.

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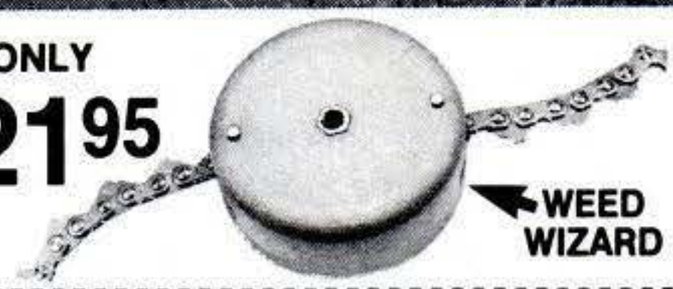

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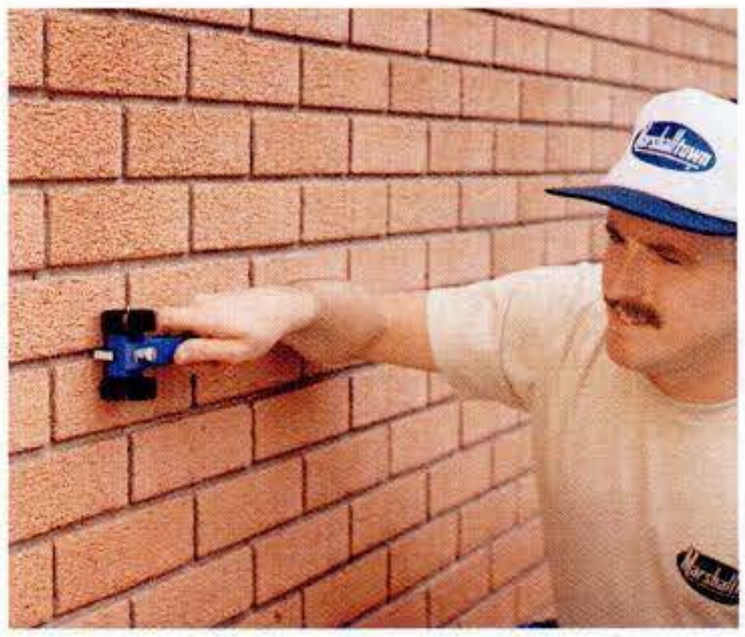

On a roll: Push Jointmaster over brickwork to scrape out old mortar, and then shape and seal the new.

With the Jointmaster, a hand-rolled pointing tool made by the British Excalibur Hand Tools Ltd., you need no special skills to make your own professional-looking mortar joints between bricks or paving stones. And you can do the job in half the time it would take using traditional methods, claims the maker.

Used for both raking out old mortar and forming new joints, the Jointmaster carries the shaping tools between a pair of nylon wheels. Clamped to one side of the handle base, the rake cleans out and primes the joint to an even depth as you roll the tool over the brick face. Each hardened and tempered steel rake (three are supplied with the tool) is claimed to be able to clean the joints of 5,000 bricks.

When you're finished raking, a pointing iron slotted into the reverse side of the tool can then be used to shape and compress simultaneously new mortar troweled into the groove. This seals the joint against water penetration and frost damage and creates a smooth finish, with no debris on the lips of the bricks. Forming-iron inserts retained by a knurled screw are available in four different profiles for square, curved, sloping, and arrowhead joints (the first two come with the tool). Because the iron is curved and centered on the wheel axis, the tilt of the handle does not affect the result, so the tool can be used with either hand. The Jointmaster's wheels can be removed for use on rustic, irregular brickwork. A compartment in the tool's maple handle holds spare rakes and shims.

The Jointmaster sells for about $20. The U.S. distributor is Marshalltown Trowel Co. (Box 738, Marshalltown, Iowa 50158).—*David Scott*

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A clinic on cars by Smokey Yunick, America's most famous mechanic

Noisy Honda

I own a 1980 Honda Civic equipped with a 1,488-cc engine that has 120,000 miles on it. I am having a problem with a pinging noise coming from the engine. I have tried retarding the ignition timing, replacing the timing belt, distributor cap, rotor, spark plugs, ignition wires, EGR valve, and coil, but it still pings. I can't think of anything else to do.
Howard Oxman, Thousand Oaks, Calif.

Your car or any other gasoline-powered vehicle will ping when exact control of the fuel-burning reaction is lost. In order of importance, the reasons for this condition are: too much ignition timing advance; too-high compression ratio for the fuel used; combustion-chamber temperature too high; small quantity of lube oil in the combustion chamber; fuel mixture too lean. Your car's pinging can have more than one cause.

Sometime brakes

I have a 1983 Mercury Grand Marquis that has a problem with the brakes. Several times in the last couple of years when I have stepped on the brake pedal it felt as if I was pushing against a brick wall. When I applied the brakes, it felt as if the brakes were at half power. After I pumped the pedal a couple of times, the brakes felt fine. When I pushed on the pedal extra hard, full braking power returned. What sort of problem should I be looking for?
Steve Ostash, Bay City, Mich.

It sounds as if your power-assist system isn't working all the time. Check for a plugged vacuum source or an internal booster problem. When your foot activates the vacuum-assist trigger, you must have enough vacuum to operate the power-assist unit. Physically examine the interior of all vacuum orifices and conduits. If they look OK, your next step is to check the assist unit itself. This type of brake problem is potentially dangerous, so don't fool around with it.

To spin or not to spin

What is your opinion of dynamic wheel balancing versus static balancing? I have always thought that spinning the wheels on the vehicle was the way to go because you are balancing all rotating components, as opposed to just the wheel.
James Edberg, Grand Bay, Ala.

You are correct that spinning total rotating parts is the best way to balance a wheel. Unfortunately it isn't that simple. The problem is that there is feedback from the bearings, gears, and axles that complicates things. Also, there is brake drag to contend with. So the spin balance is used as the best quick fix to solve problems at the lowest cost.

More horses

I have a 1981 Dodge Omni with a 2.2-liter engine. At the time I bought the car, this size engine was rated at 84 horsepower. I understand that Chrysler has figured out how to get more power from this engine. Is there anything I can do to increase the horsepower of my engine?
Richard F. Shoppe, Whiting, N.J.

Nope. There is no way that makes economic sense and would be legal and reliable for you to boost the engine's output. The best way for you to get more horsepower out of the engine is to turbocharge it. But it will be at considerable cost and could shorten the life of the engine unless it is well done.

Shift stalling

My 1987 2.8-liter V6 Cavalier Z-24 has gradually developed the habit of stalling when I shift it into gear and put load on the engine. This only happens when the car has been sitting overnight. If I let the engine run unloaded for 15 to 30 seconds then put the car into gear, it usually does not stall, although it will run rough for a few seconds. At all other times it runs perfectly. My Chevrolet dealer has no idea why this is happening, so he recommended a tuneup, which he did, with no effect. Another Z-24 owner told me he had the same problem and was never able to get it resolved. What do you think the problem is, and how can it be fixed?
John Horst, Moretown, Vt.

The mixture on cold start is too lean. Your engine is computer controlled with reference to fuel, ignition, and emissions. The engine has many sensors

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that talk to the computer. All cold engines need a little extra-rich fuel-air mixture to start. There is also a critical emissions problem, with the mixture being important to hold emissions to an absolute minimum on a cold start. Your problem must be examined with an engine analyzer for fuel mixture, ignition, and timing when the engine is cold started.

Leaded-gas replacement?

In the past I have been led to believe that any engine that was designed to run on leaded gasoline requires it. Now Shell has come out with a pamphlet saying its SR 2000 unleaded gas can be used instead of leaded gas. Is this true? Will it damage my car?

Louis Di Meglio, Old Bethpage, N.Y.

If you read the pamphlet carefully, it says what I've been saying for years: If you don't run your leaded-gas vehicle hard, you'll get by with only some affordable extra maintenance using unleaded fuel. The only problem with using unleaded fuel in your leaded-gas-designed engine (assuming you get the correct octane fuel for your car) is that lead is needed to lubricate the exhaust-valve-seat interface. With the lead reductions mandated by the government, gasoline producers want to get out of the leaded-fuel business. So we have come to the end of the road. Either replace your vehicle with newer equipment or have your vehicle's engine overhauled with hard-faced valves and seats (exhaust side only). I realize marine and farming equipment users whose engines need leaded gasoline will be hard hit by this. But if a kit was offered by the engine manufacturers to install hardened valve seats, it wouldn't be too expensive a job to do. The price of progress is once again trouble.

Cranky starter

Would you please help me solve a problem with my 1986 eight-cylinder Pontiac station wagon? The engine refuses to start readily when cold after sitting in the garage overnight. The car was purchased new and has been driven only 9,800 miles. The instructions on a small card on the visor say to depress the accelerator pedal slowly, then turn the ignition key. This does not work. The only way to start the car when cold is to pump the accelerator pedal four times.

Robert F. Seubert
Wexford, Pa.

The fuel-air mixture on cold starts is probably too lean. The carburetor could be leaking internally, or the bowl may have become so hot while driving that the fuel expands when the car is parked. This can cause a thermosiphon in which the fuel is forced out of the carburetor bowl into the intake manifold. Emissions-control equipment could be playing a role in this problem as well. The fume canister and exhaust-gas-recirculation system must be plumbed correctly and operating properly for an easy cold start-up. The automatic choke and its controls and carburetor air-temperature controls are involved, and the exhaust manifold heat is part of a cold start.

Got a car problem? Send it to "Say, Smokey—," POPULAR SCIENCE, 380 Madison Ave., New York, N.Y. 10017. All letters are read, and those of widest interest are answered in this column. Due to the large volume of mail, Smokey cannot reply to letters not selected for publication.

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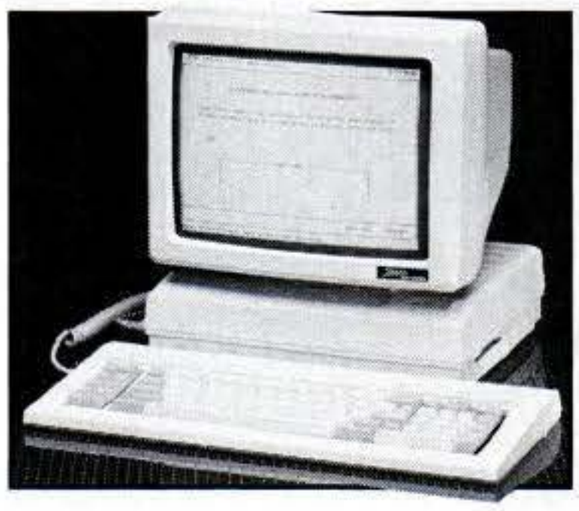

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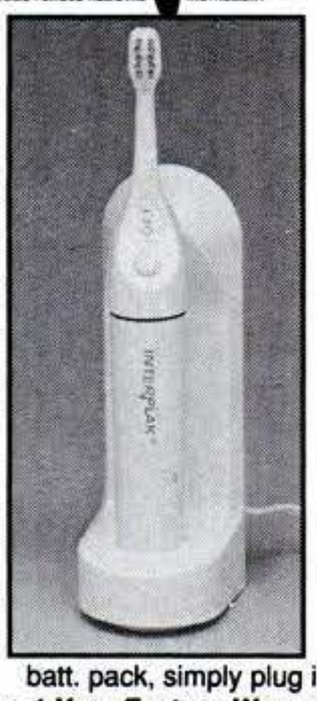

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Save Gas, Save Engine with 'POLY'

DOUBLE GUARANTEE (See Details Below)

The following introduces one of the most fully tested and credentialed gas saving, friction reducing engine treatments ever to reach the market!

WHAT IS POLY? "Poly" is short for polytetrafluoroethylene (TFE). It is the slipperiest substance known to man. **The 1988 Guinness Book of World Records (pg. 182) says:** *"The lowest coefficient of static and dynamic friction of any solid is 0.02, in the case of Polytetrafluoroethylene -equivalent to wet ice on ice. It was first manufactured in quantity by E.I. duPont in 1943, and is marketed as Teflon™."*

The PetroLon Corporation, makers of Slick 50, have invented a way to permanently bind this slippery chemical to your engine with one treatment. All you do is add one quart of Slick 50 to your oil during oil and filter change. By reducing engine friction, Slick 50 increases gas mileage and horsepower and reduces engine operating temperature thus causing your oil and engine to last longer. Just as important, it reduces metal wear, defraying costly overhauls.

Slick 50's credentials are impressive.

"Slick 50 does reduce engine heat and ordinary wear, and our informal tests indicate that it will improve gas mileage by about two or three miles per gallon...Slick 50 does exactly what PetroLon claims it does." Consumers Digest,(March/April 1982, p. 35)

Researchers at a **nationally respected research laboratory,** after applying a powerful ultrasonic cleaning process to a Slick 50 treated engine part, were surprised at its permanence. They stated, "We actually expected the PetroLon Slick 50 'Poly' resin coating to also be removed, but later found it was still there."

The Federal Aviation Administration has fully accepted a similar product – Slick 50 Aircraft Treatment (F.A.R. #33.49).

TUV, a German testing laboratory with credentials every bit as prestigious as our Underwriters Laboratories, tested Slick 50 in 1986. They found substantial increases in both gas mileage and horsepower. Their tests showed that these gains were due to a reduction in friction.

A test done at the **San Diego State University** revealed that, "Slick 50 does increase horsepower and decreases fuel consumption in tests done at the university." The **Space Shuttle Columbia** uses the chemical "poly" in its gears and bearings because it is the only chemical lubricant which can withstand the heat and corrosive elements of space.

Perhaps the most dramatic of all is a torture test overseen by the Automotive Services Council for Pennsylvania. This test was shown on television station WTVE: Three cars with between 75,000 and 129,000 miles on them, were treated with Slick 50. Six months later the oil was drained from each vehicle and the cars were driven without the oil plugs for about half an hour. The water temperature never rose and the engines sustained no apparent damage.

How do you give an engine a "poly" treatment? Very simply! Just before an oil and filter change, add Wynn's™ Engine Flush (sent **free with each order)** to clean out your engine. Then drain your oil, change the filter, and add the proper amount of oil less one quart. Add one quart of Slick 50, drive for thirty minutes, and leave it in the crankcase for 3,000 miles. (Add two quarts for engines with oil capacities of seven quarts or more.)

Slick 50 gives a permanent coating so you need to treat your engine only once, and not each time you change your oil. Slick 50 is also excellent for turbocharged engines, aluminum block engines and rotary engines.

Will it work with most oil? Yes! Slick 50 will work with all petroleum-based oils and synthetics compatible with petroleum based oils.

What are the benefits of Slick 50? Your actual benefits in percentages may vary, depending on the kind of driving you do, the condition of your vehicle, etc. By reducing friction, Slick 50 does all of the following: Slick 50 **increases gas mileage.** Slick 50 **increases horsepower** - small economy cars and large RV's really need this! Slick 50 **makes for easier starting** (important in cold weather.) Slick 50 **reduces operating temperatures,** thus increasing the lubrication of your oil and the life of your engine. Since lubricating lead is being removed from gas, and unleaded gas is poor in lubricating qualities, **this extra lubrication of Slick 50 on valve systems and guides is a real bonus.**

Last, but not least, the drastic reduction in engine wear can delay costly overhauls. These can often cost well over $1,000. Slick 50 eliminates the "lubrication starvation" that all cars experience when you first start them, before the oil has a chance to circulate. Up to 90% of the wear on a car can be caused by this lubrication starvation. You receive all these benefits for less than the cost of two tanks of gas ($39.95).

Will Slick 50 harm my engine or affect my warranty? No! Slick 50 is suspended in an excellent grade of petroleum oil which meets, or exceeds, every manufacturer's engine warranty requirements. In addition, this oil carries an API (American Petroleum Institute) service classification SF-CC-CD.

More Slick 50 products are available. These include Gear Treatment (manual transmission, etc.) 2-Cycle Engine Treatment, Grease, Fuel Conditioner, and Power Boost. Free information sent on request.

DOUBLE GUARANTEE!

Guaranteed lowest price and guaranteed satisfaction. If at the time of purchase you have seen Slick 50 advertised in a current magazine at a lower price, we will beat that price by $2.00 a quart and you will still get your free engine flush. If you are not satisfied with our Slick 50, within 4 months, send us a note and proof of purchase for a full refund of purchase price. This makes trying Slick 50 **RISK FREE** to you. We have been in business for 10 years and intend to keep our customers happy.

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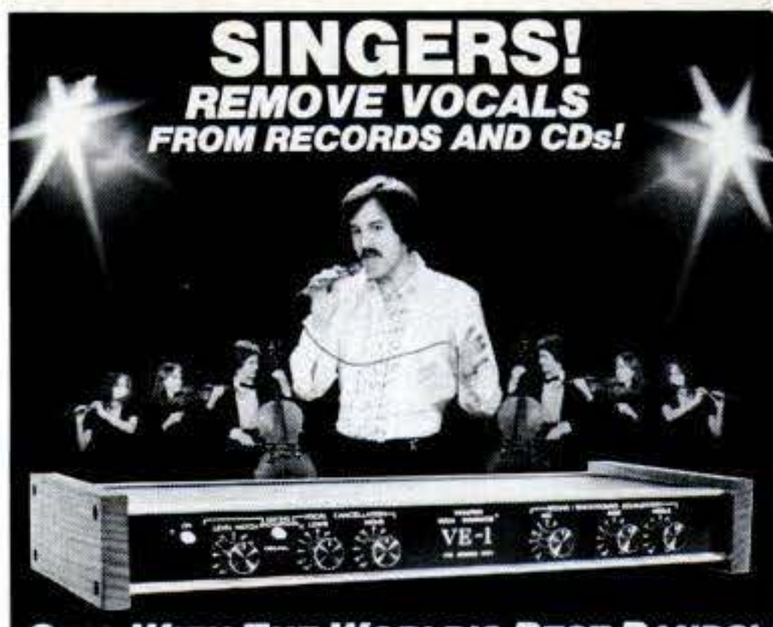

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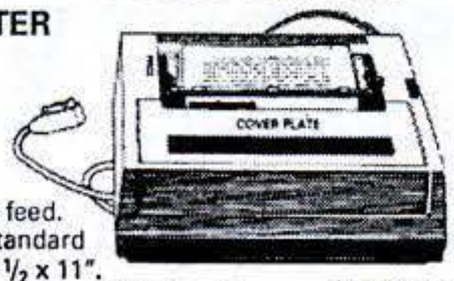

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10Mb

(ST 212 Compatible)

Mfr – Tandon #TM252

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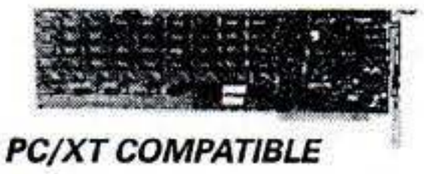

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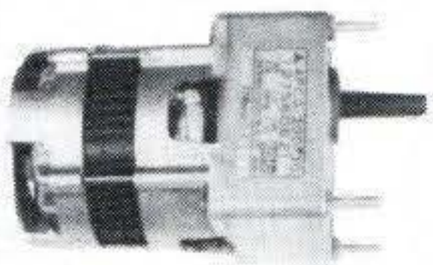

Reversible capacitor induction motor. 115V/60 Hz., 30 in./lb. torque. 14W. Front flange mount. OA Dimen: 3¼" dia. x 5" long; Shaft: ⅜" dia. x 1" long. Mfr — Matsushita or equiv.

Item #5149 **$9.95** RFE

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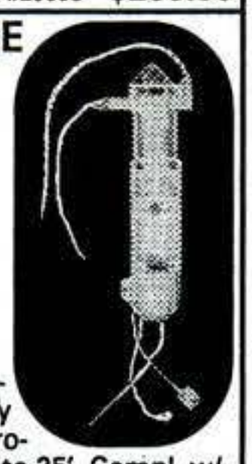

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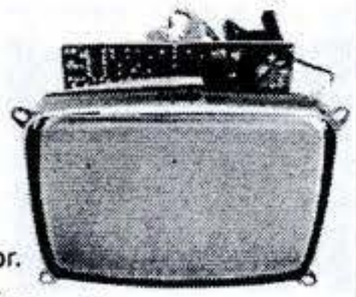

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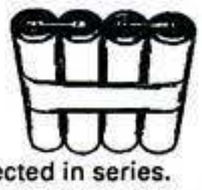

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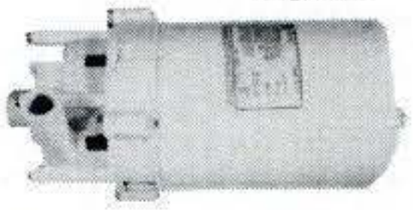

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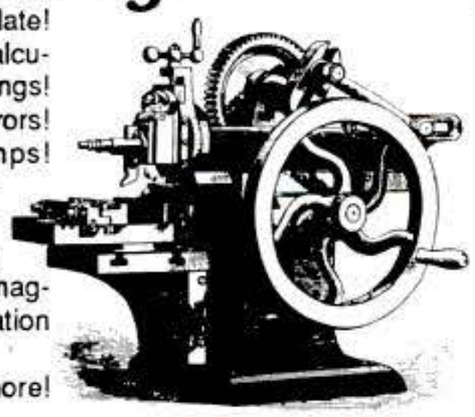

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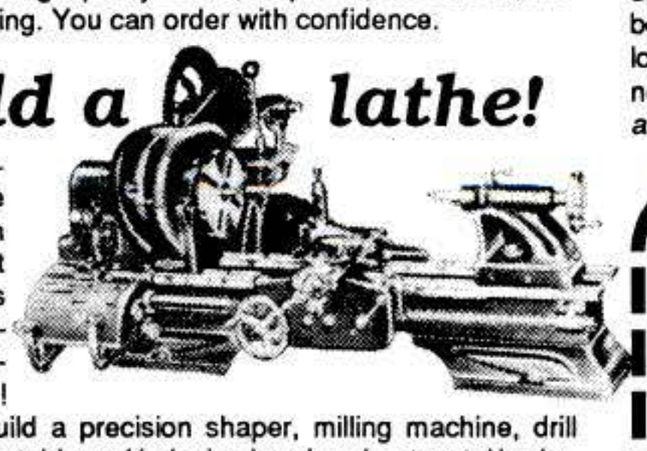

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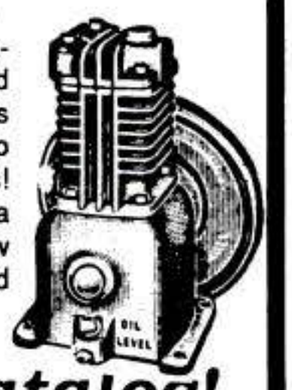

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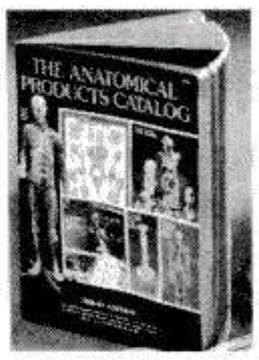

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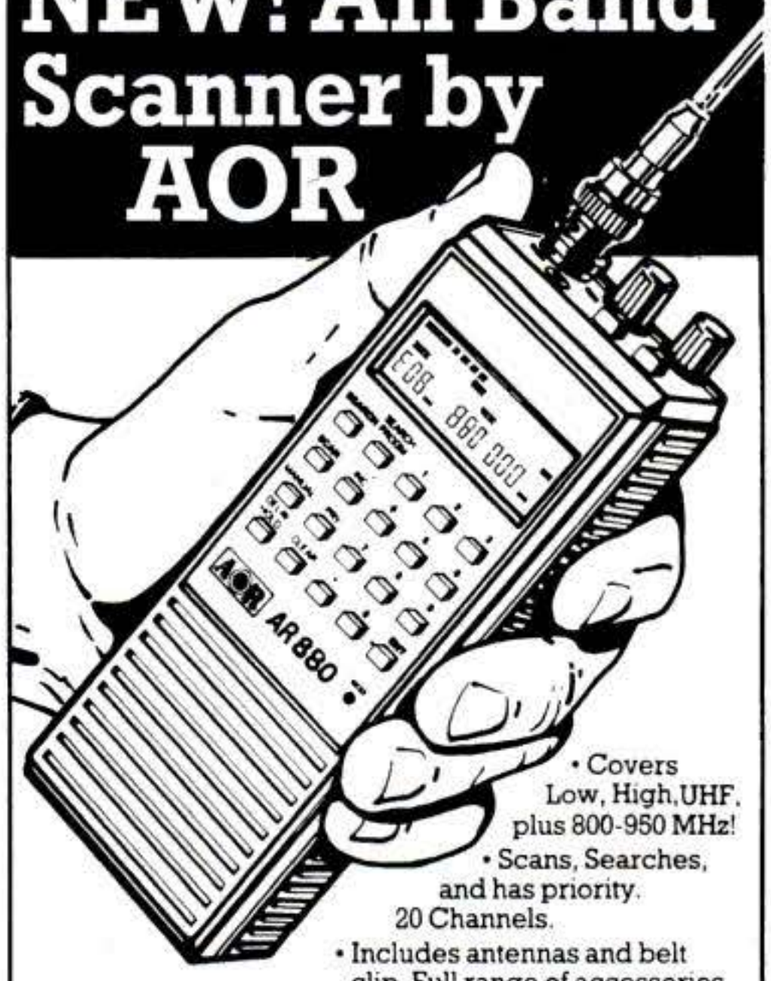

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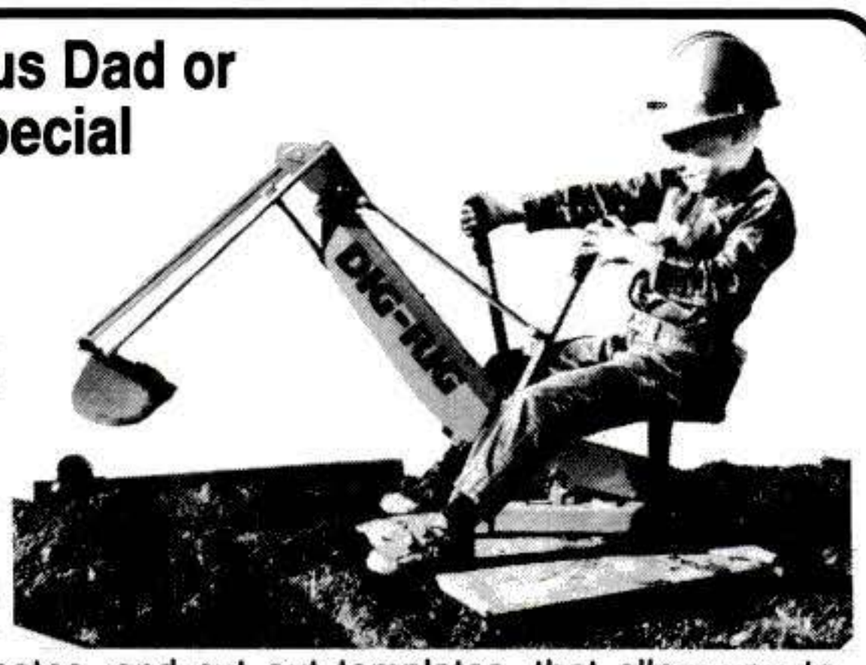

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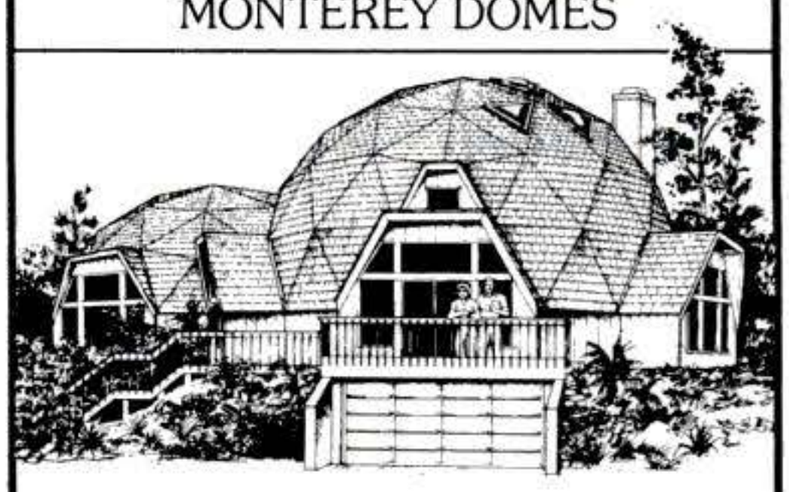

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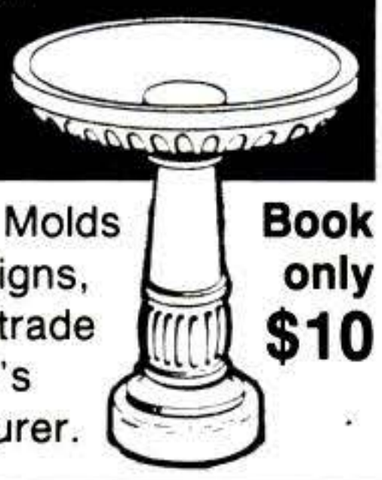

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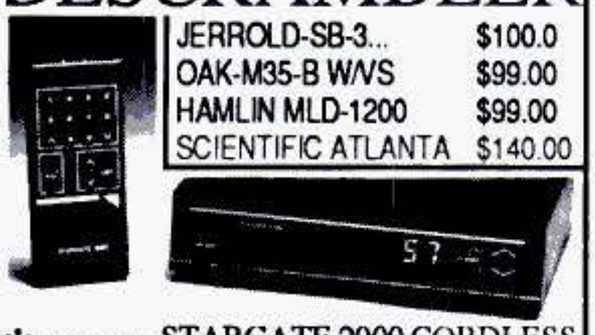

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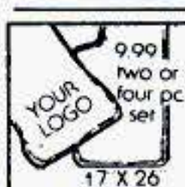

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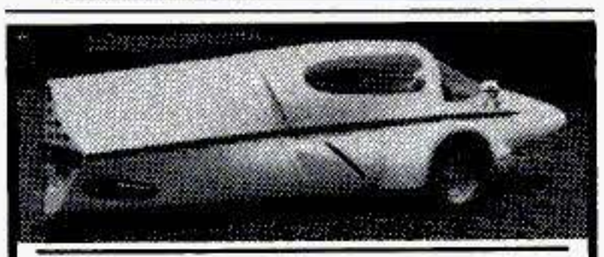

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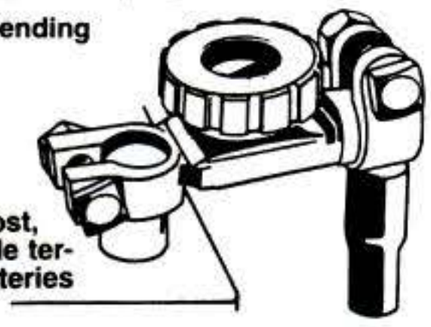

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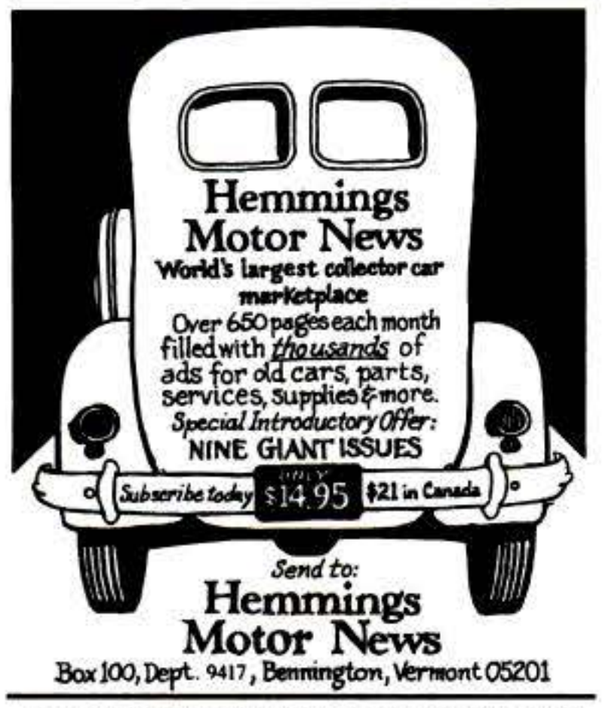

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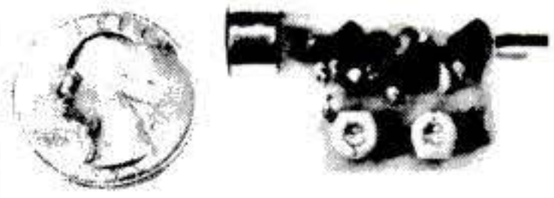

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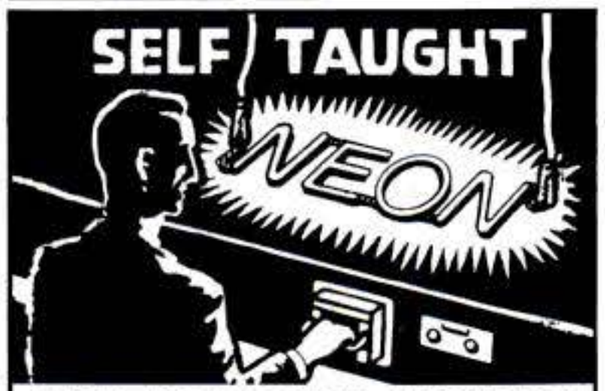

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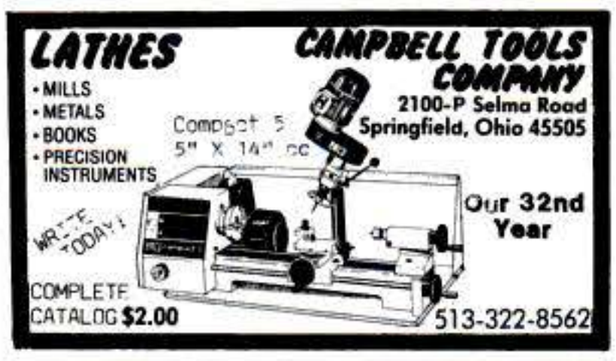

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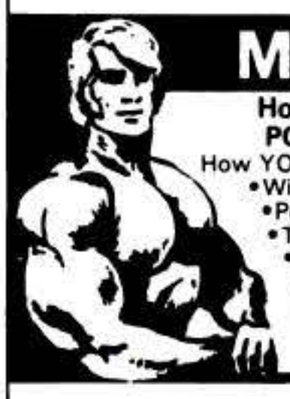

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